SCIENCE, AERONAUTICS AND TECHNOLOGY
FY 2003 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE SCIENCE
Web Address: http://spacescience.nasa.gov

SUMMARY OF RESOURCE REQUIREMENTS

	FY 2001 OP PLAN REVISED	FY 2002 INITIAL OP PLAN	FY 2003 PRES BUDGET	Page Number
		(Millions of Dollars)		
Development Programs:				
Space Infrared Telescope Facility (SIRTF)	118.3	113.0	47.4	SAT 1-7
Hubble Space Telescope (HST)	179.5	172.0	138.9	SAT 1-11
Gravity Probe-B (GP-B)	41.2	46.1	19.7	SAT 1-15
Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)	13.3	4.2		SAT 1-18
Stratospheric Observatory For Infrared Astronomy (SOFIA)	43.1	38.0	46.9	SAT 1-21
Solar Terrestrial Relations Observatory (STEREO)		52.9	74.3	SAT 1-24
Gamma-ray Large Area Space Telescope (GLAST)		20.7	69.2	SAT 1-27
New Frontiers			15.0	SAT 1-31
Payload and Instrument Development	39.6	47.5	38.0	SAT 1-32
Explorers	141.3	125.2	135.1	SAT 1-38
Discovery	213.0	214.6	207.7	SAT 1-45
Mars Exploration Program (MEP)	429.5	414.7	453.6	SAT 1-51
Mission Operations	122.8	174.8	385.2	SAT 1-60
Technology Program	353.2	440.2	703.9	SAT 1-68
Research Program	613.0	646.5	709.6	SAT 1-89
Investments	13.2			
Institutional Support	285.6	356.7	369.8	SAT 1-98
Total	**2,606.6**	**2,867.1**	**3,414.3**	

OFFICE OF SPACE SCIENCE

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION

	FY 2001	FY 2002	FY 2003
	(Millions of Dollars)		
Johnson Space Center	20.2	20.1	18.2
Kennedy Space Center	114.5	152.8	148.8
Marshall Space Flight Center	171.0	216.4	243.7
Ames Research Center	107.7	105.8	116.8
Langley Research Center	36.0	18.0	18.0
Glenn Research Center	13.3	8.9	93.3
Goddard Space Flight Center	1061.4	1215.0	1318.6
Jet Propulsion Laboratory	975.4	934.3	1158.3
Dryden Flight Research Center	0.3	0.2	0.2
Stennis Space Center	--	--	--
Headquarters	106.8	195.6	298.4
Total	**2,606.6**	**2,867.1**	**3,414.3**

SPACE SCIENCE STRATEGIC PLAN LINKAGE TO THIS BUDGET

Thousands of years ago, on a small rocky planet orbiting a modest star in an ordinary spiral galaxy, our remote ancestors looked up and wondered about their place between Earth and sky. On the threshold of the 21st century, we ask the same profound questions:

- How did the universe begin and evolve?
- How did we get here?
- Where are we going?
- Are we alone?

Today, after only the blink of an eye in cosmic time, we are beginning to answer these questions. Using tools of science that range from abstract mathematics and computer modeling to laboratories and observatories, humans are filling in the details of the amazing story of the universe. In the last 40 years, space probes and space observatories have played a central role in this fascinating process, and NASA's Space Science Enterprise will continue to address these four profound questions:

How did the universe begin and evolve? We seek to explain the earliest moments of the universe, how stars and galaxies formed, and how matter and energy are entwined on the grandest scales. We study astrophysical objects, such as neutron stars and black holes, with extreme conditions that demonstrate fundamental laws of physics at work. We study the behavior of matter, radiation, and magnetic fields under less severe conditions, in the giant laboratory of our Solar System. The understanding thus gained applies directly to the history and behavior of stars and galaxies.

How did we get here? We investigate how the chemical elements necessary for life have been built up and dispersed throughout the cosmos. We look for evidence about how the Sun has behaved over time and what affect this has had on Earth and everything on it. We send probes to other planets to learn about their similarities and differences as keys to how they formed and evolved, and study the comets and asteroids in our Solar System for clues to their effects on the evolving Earth. We carry out ground-based research on the environmental limits of life to learn how it might have arisen and evolved on early Earth.

Where are we going? Our ultimate place in the cosmos is wrapped up in the fate of the universe. Nearer to home, the variability of our Sun and vulnerability of Earth to possible impacts by small Solar System bodies are being investigated. We are comparing the climate histories of Earth and its sibling planets. Humanity has taken its first steps off our home world, and we will contribute to making it safe to travel throughout the Solar System and will ascertain what resources possible destinations could offer to human explorers.

Are we alone? Beyond astrophysics and cosmology, there lies the central human question: Are we on Earth an improbable accident of nature? Or is life, perhaps even intelligent life, scattered throughout the cosmos? We seek to explain how planets originated around our Sun and other stars— planets that might support life. We observe nearby stars for indirect evidence of other planets, and look to the future when advanced observatories in space might be able to directly image such relatively small objects across the vast interstellar void. Beginning with life found in astonishing places on Earth, we conjecture about what kinds of environments could bear and support life, and how common habitable planets might be. Is there now, or has there ever been, life in our own Solar System other than on Earth?

Answers to these deep questions will not be extracted from narrow inquiries, but will be built up by combining innumerable individual clues over the years to come. The broad outlines of much of the puzzle are discernible now, but a clear picture of the whole awaits years of varied research that will undoubtedly produce many surprises along the way. In order to structure the scientific research, Space Science has established the following goals, objectives, and research focus areas:

<u>Enterprise Goals</u> (from NASA Strategic Plan)	**<u>Science Objectives</u>** (From Space Science Enterprise Strategic Plan)	**<u>Research Focus Areas</u>** (From NASA Performance Plan)
Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life	Understand the structure of the universe, from its earliest beginnings to its ultimate fate	• Identify dark matter and learn how it shapes galaxies and systems of galaxies • Determine the size, shape, age, and energy content of the universe
	Explore the ultimate limits of gravity and energy in the universe	• Discover the sources of gamma ray bursts and high energy cosmic rays • Test the general theory of relativity near black holes and in the early universe, and search for new physical laws using the universe as a laboratory • Reveal the nature of cosmic jets and relativistic flows
	Learn how galaxies, stars, and planets form, interact, and evolve	• Observe the formation of galaxies and determine the role of gravity in this process • Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms • Observe the formation of planetary systems and characterize their properties • Use the exotic space environments within our Solar System as natural science laboratories and cross the outer boundary of the Solar System to explore the nearby environment of our galaxy
	Look for signs of life in other systems	• Discover planetary systems of other stars and their physical characteristics • Search for worlds that could or do harbor life
	Understand the formation and evolution of the Solar System and Earth	• Inventory and characterize the remnants of the original material from which the Solar System formed • Learn why the planets in our Solar System are so different from each other • Learn how the Solar System evolves

Enterprise Goals		**Science Objectives**	**Research Focus Areas**
		Probe the origin and evolution of life on Earth and determine if life exists elsewhere in our Solar System	• Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds • Determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life • Chart the distribution of life-sustaining environments within our Solar System, and search for evidence of past and present life • Identify plausible signatures of life on other worlds
		Understand our changing Sun and its effects throughout the Solar System	• Understand the origins of long- and short-term solar variability • Understand the effects of solar variability on the solar atmosphere and heliosphere • Understand the space environment of Earth and other planets
		Chart our destiny in the Solar System	• Understand forces and processes, such as impacts, that affect habitability of Earth • Develop the capability to predict space weather • Find extraterrestrial resources and assess the suitability of Solar System locales for future human exploration

Each Space Science program and mission is linked to these Goals, Objectives, and Research Focus Areas, as specified in the section for each program that follows.

SIGNIFICANT NEW FEATURES IN THE FY 2003 BUDGET

Within the Solar System Exploration Focused Technology Program, a new Nuclear Electric Propulsion program will enable: 1) significant reductions in the cruise time for spacecraft to reach distant targets; 2) the use of smaller launch vehicles thereby reducing total mission costs; 3) entire new classes of planetary exploration missions that can carry out in-depth research at multiple planetary targets; 4) reduced operation costs by reducing the amount of time a spacecraft is in its operations phase; 5) reduction or elimination of launch windows required for gravity assists; and 6) less expensive and more frequent missions.

Also within the Solar System Exploration Focused Technology Program, a new Nuclear Power program offers the potential to dramatically increase the potential scientific return of many future missions, by increasing the operational lifetime and productivity of spacecraft and instruments; enabling multiple landers on a single mission; providing energy for high-power planetary survey instruments for remote sensing and deep atmosphere probes; and allowing high bandwidth communications. Within the Mars Exploration program, nuclear power has been incorporated as an element of the 2009 Mars Smart Lander/Mobile Laboratory mission, and will greatly extend the duration of surface operations, thereby significantly increasing scientific return.

A new program called New Frontiers is a revamping of the Outer Planets missions program. The program will provide frequent access to space for mid-sized planetary missions that will perform high-quality scientific investigations. New Frontiers will be structured and managed along the lines of the highly successful Discovery program. New Frontiers will pursue a clear set of goals and science priorities, and will select missions through a fully open and competitive process.

A large part (over $200 million) of the apparent increase from FY 2002 to the FY 2003 Budget request is not an increase at all, but is due to the transfer of funding and responsibility for two critical components of Space Science spacecraft operations (the Deep Space Network, and Mission Services for Space Science missions) from the Office of Space Flight. These elements are now part of Space Science's Mission Operations budget. See page MY-2 for a normalized comparison of NASA's FY 2001, FY 2002, and FY 2003 budgets.

BASIS OF FY 2003 FUNDING REQUIREMENT

Space InfraRed Telescope Facility (SIRTF)

Web Address: http://sirtf.caltech.edu

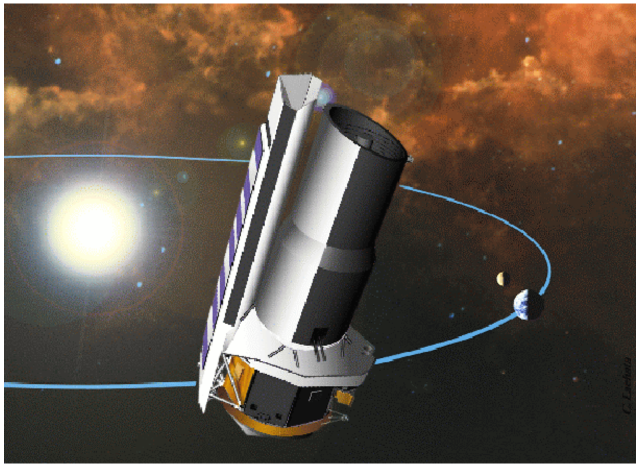
	FY 2001	FY 2002	FY 2003
SIRTF Development *	**118.3**	**113.0**	**47.4**

* SIRTF Total life cycle cost data is provided at the end of this section.

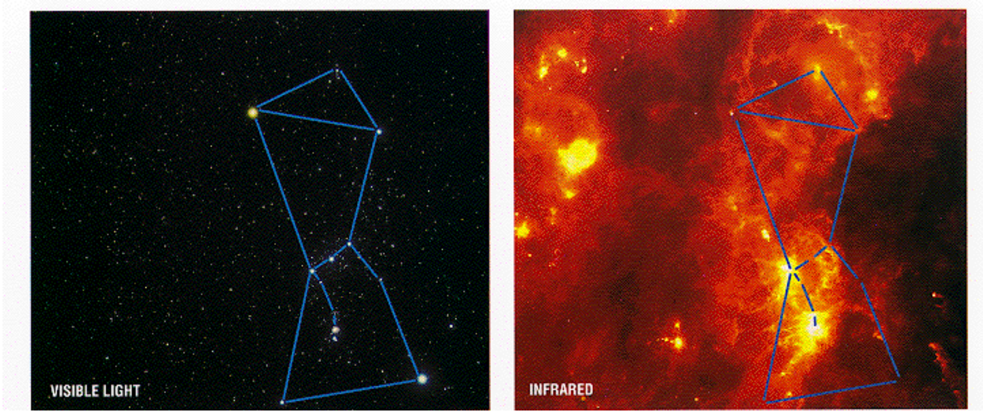
DESCRIPTION / JUSTIFICATION

The Space Infrared Telescope Facility (SIRTF) will explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. Exploiting these windows requires a cryogenically cooled telescope, limited in sensitivity only by the faint infrared glow of the interplanetary dust. These windows allow infrared observations to explore:

- The *cold* Universe by looking at heat radiation from objects which are too cool to radiate at optical and ultraviolet wavelengths;
- The *hidden* Universe by penetrating into dusty regions which are too opaque for exploration in the other spectral bands;
- The *distant* Universe by virtue of the cosmic expansion, which shifts the ultraviolet and visible radiation from distant sources into the infrared spectral region.



SIRTF is the fourth and final of NASA's Great Observatories, which include the Hubble Space Telescope, Compton Gamma Ray Observatory, and the Chandra X-Ray Observatory.



Views of the constellation Orion dramatically illustrate the difference between the familiar, visible light view and the richness of the Universe accessible in the infrared part of the spectrum

SIRTF ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	SIRTF APPROACH
How do galaxies form and evolve?	SIRTF's deep surveys will determine how the number and properties of galaxies changed during the earliest periods of the Universe.
What engine drives the most luminous objects in the Universe?	SIRTF will study the evolution with cosmic time of extremely luminous galaxies and quasar populations and probe their interior regions to study their energy sources.
Is the mass of the Galaxy hidden in sub-stellar objects and giant planets?	SIRTF will search for cold objects with mass less than 0.08 times that of the Sun, not massive enough to ignite nuclear reactions, which may contain a significant fraction of the mass of the Galaxy.
Have planetary systems formed around nearby stars?	SIRTF will determine the structure and composition of disks of material around nearby stars whose very presence implies that these stars may harbor planetary systems.
What lies beyond?	SIRTF's greater than 1000-fold gain in astronomical capability beyond that provided by previous infrared facilities gives this mission enormous potential for the discovery of new phenomena.

While these scientific objectives drive the mission design, SIRTF's powerful capabilities have the potential to address a wide range of other astronomical investigations. SIRTF should be able to make substantial progress in NASA's efforts to understand the formation of planetary systems; SIRTF's measurements of the density and opaqueness of the dust disks around nearby stars will help set the requirements for future missions designed to directly detect planets.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate; and learn how galaxies, stars, and planets form, interact and evolve.

Performance Plan Metrics Supported: When operational, SIRTF will support Annual Performance Goal (APG) #3S1, "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Identify dark matter and learn how it shapes galaxies and systems of galaxies.
- Determine the size, shape, age and energy content of the universe."

and APG #3S3, "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms.
- Observe the formation of planetary systems and characterize their properties.

Milestones	FY02 Budget Date	FY03 Budget Date	Change	Comment
Launch	7/02	NET 12/02	+5 mos	Flight software readiness delays; 12/02 launch readiness date used for development of budget estimates; launch date and budget are under review

Lead Center: JPL	**Other Centers:** GSFC/ARC/KSC	**Interdependencies:** No other partners
Subsystem	**Builder**	
Spacecraft:	Lockheed Martin: Sunnyvale, CA	
Cryogenic Telescope Ass'y:	Ball; Boulder, CO	
Instruments	**Builder**	**Principal Investigator**
IRS	Cornell	Houck
MIPS	U. Arizona	Rieke
IRAC	Smithsonian Astronomical Observatory	Fazio
Launch Vehicle:	**Tracking/Communications:**	**Data:**
Boeing Delta 7920H	Deep Space Network	Infrared Processing Analysis Center (IPAC), Cal Tech

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

As a result of software development delays and anomalies during integration and test, the launch date has slipped from last year's plan. The budget estimates support a December 2002 launch, but the date may slip a few months further. All instruments have now been integrated into the CryoTelescope Assembly. The Telescope Acceptance Review was completed in January 2001; the Telescope meets or exceeds all Level 1 science requirements. The telescope has also been integrated into the Cryogenic Telescope Assembly, which has been successfully performance tested and is expected to be shipped to Lockheed for integration in early CY 2002. Observatory-level testing will continue through the balance of FY 2002.

PROGRAM PLANS FOR FY 2003

Shipment of the completed SIRTF observatory to KSC is expected in early FY 2003, followed by launch and a 60-day in-orbit checkout period before transition to science operations.

SIRTF LIFE CYCLE COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	TOTAL
FY 2003 President's Budget	393.2	118.3	113.0	79.1	68.5	70.0	70.0	73.8	155.1	1,141.0
Pre-Development Studies	79.9									79.9
Development	281.4	106.4	91.3	47.4						526.5
Launch Services	31.9	11.9	21.7							65.5
Operations				3.2	7.3	6.3	5.3	6.5	9.1	37.7
Data Analysis				28.5	61.2	63.7	64.7	67.3	146.0	431.4
[Estimated Civil Servant FTE]		24	12							

BASIS OF FY 2003 FUNDING REQUIREMENT

Hubble Space Telescope (HST) Development

Web Address: http://hubble.gsfc.nasa.gov

	FY 2001	FY 2002	FY 2003
HST Development *	**179.5**	**172.0**	**138.9**

* HST Total life cycle cost data is provided at the end of this section.

DESCRIPTION / JUSTIFICATION

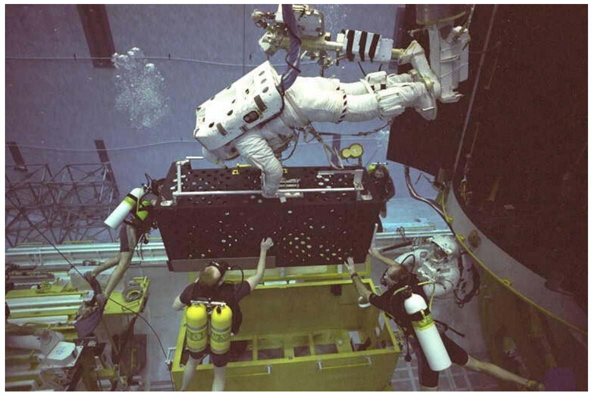
Not since Galileo turned his telescope towards the Heavens in 1610 has any event so changed our understanding of the Universe as the deployment of the Hubble Space Telescope.

Hubble orbits 600 Kilometers above Earth, working around the clock to unlock the secrets of the Universe. It uses excellent pointing precision, powerful optics, and state-of-the-art instruments to provide stunning views of the Universe that cannot be made using ground-based telescopes or other satellites. Hubble was originally designed in the 1970s and launched in 1990. Thanks to on-orbit service calls by the Space Shuttle astronauts, Hubble continues to be a state-of-the-art space telescope.

Hubble is the first scientific mission of any kind that is specifically designed for routine servicing by spacewalking astronauts. It has a modular design, which allows the astronauts to take it apart, replace worn out equipment and upgrade instruments. These periodic service calls make sure that Hubble produces first-class science using cutting-edge technology.

The HST Development budget supports these periodic Servicing Missions, as well as modification and upkeep of ground operations systems. Operations and data analysis costs are not included here. Servicing missions are currently planned for early 2002 (SM3B) and 2004 (SM4), after which NASA plans to operate HST until 2010 without further servicing missions, to enable development of a follow-on telescope to Hubble, the Next Generation Space Telescope.

Astronauts training for Servicing Mission 3B; activities during Servicing Mission 2



HST ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	HST APPROACH
How many galaxies and clusters formed in the early Universe?	Install the Advanced Camera for Surveys (ACS) during SM3B to study the nature and distribution of galaxies in the early Universe
What can we learn by studying wavelengths of light (e.g., near infrared) that do not penetrate Earth's atmosphere?	Install the NICMOS Cryocooler during SM-3B to enable several years of near-infrared astronomical investigations
How did large-scale structure originate in the early Universe?	Install the Cosmic Origins Spectrograph (COS) during SM4 to observe high-energy activities (such as those found in new hot stars and Quasi Stellar Objects) at near- and mid-ultraviolet wavelengths.
How have galaxies evolved?	Install the Wide Field Camera 3 (WFC3) during SM4, replacing the WF-PC2 (which will be 10 years old). WFC3 will use the latest CCD technology and will maintain good imaging capabilities throughout the life of Hubble's mission.

HST will address the scientific questions above, and many others. HST has repeatedly stretched our knowledge of the Universe in ways that had not been anticipated. With the scientific capabilities to be provided by the next generation of instruments, HST will remain on the forefront of astronomical research.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate; and understand the formation and evolution of the Solar System and Earth within it.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."
Note: HST operations support Annual Performance Goal (APG) #3S1, "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Identify dark matter and learn how it shapes galaxies and systems of galaxies.
- Determine the size, shape, age and energy content of the universe."

and APG #3S3, "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms.
- Observe the formation of planetary systems and characterize their properties."

Milestones	FY 2002 Budget Date	FY 2003 Budget Date	Change	Comment
SM-3B	5/02	2/02	-3 mos	Subject to Space Shuttle availability
COS System Test	FY02	FY02		

Lead Center: GSFC

Other Centers: JPL

Interdependencies: Shuttle

Instruments	Builder	Pr. Investigator
Advanced Camera for Surveys	Ball, JHU, STScI, GSFC	Holland Ford, Johns Hopkins University
Cosmic Origins Spectrograph	Ball	University of Colorado
Wide Field Camera 3	GSFC, JPL, Ball, STScI	facility-class instrument

Tracking/Communications: Tracking and Data Relay Satellites (TDRS)

Data: Space Telescope Science Institute

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

Final arrangements are being made for Servicing Mission 3B launch in early 2002. Meanwhile, development of the Cosmic Origins Spectrograph (COS) and Wide-Field Camera-3 (WFC3) continues in anticipation of Servicing Mission 4 in 2004.

PROGRAM PLANS FOR FY 2003

COS and WFC3 will undergo integration and testing prior to shipment to KSC, while astronaut training will begin and detailed plans will be made for each day of activity during SM4.

HST TOTAL COST DATA ($ in millions; excludes Shuttle costs)

	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07
FY 2003 President's Budget	256.4	257.7	228.2	164.6	125.6	130.6	134.9
Development	179.5	172.0	138.9	73.3	30.8	31.6	33.1
Operations	1.5	5.0	5.1	5.3	5.5	5.6	5.9
Data Analysis	75.4	80.7	84.2	86.0	89.3	93.4	95.9
[Estimated Civil Servant FTE]	172	174	170	121	83	86	86

BASIS OF FY 2003 FUNDING REQUIREMENT

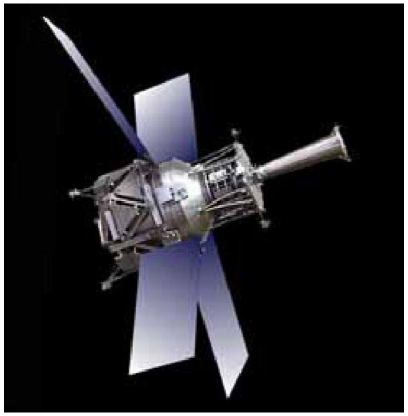
Gravity Probe B (GP-B)

Web Address: http://einstein.stanford.edu

	FY 2001	FY 2002	FY 2003
GP-B Development *	**41.2**	**46.1**	**19.7**

* GP-B Total life cycle cost data is provided at the end of this section.

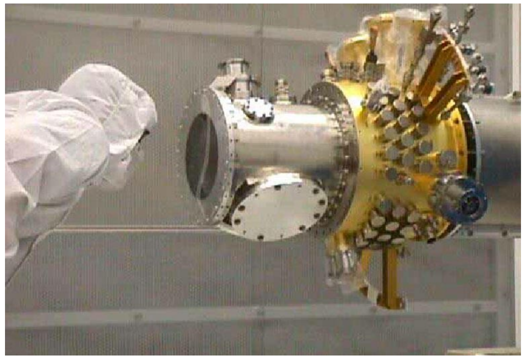
DESCRIPTION / JUSTIFICATION



The purpose of Gravity Probe B is to verify Einstein's theory of general relativity. This is the most accepted theory of gravitation and of the large-scale structure of the Universe. General relativity is a cornerstone of our understanding of the physical world, and consequently of our interpretation of observed phenomena. However, it has only been tested through astronomical observation and Earth-based experiments. An experiment is needed to explore and test more precisely the predictions of the theory in two areas: (1) a measurement of the "dragging of space" by rotating matter; and (2) a measurement of space-time curvature known as the "geodetic effect". The dragging of space has never been measured, and the geodetic effect needs to be measured more precisely. Whether the experiment confirms or contradicts Einstein's theory, its results will be of the highest scientific importance. The measurements of both the frame dragging and geodetic effects will allow Einstein's Theory to be either rejected or given greater credence. The effect of invalidating Einstein's theory would be profound, and would call for major revisions of our concepts of physics and cosmology.

In addition, GP-B is contributing to the development of cutting-edge space technologies that are also applicable to future space science missions and transportation systems.

Inspecting the GP-B telescope; the dewar will cool the instrument to just above absolute zero



LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Explore the ultimate limits of gravity and energy in the Universe.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."
When operational, GP-B will support APG #3S2, "Earn external review rating of "green," on average, on making progress in the following area:

- Test the general theory of relativity near black holes and in the early universe, and search for new physical laws using the Universe as a laboratory."

Milestones	FY 2002 Budget Date	FY 2003 Budget Date	Change	Comment
Spacecraft assembly & test	8/01	4/01	-4 mos	Spacecraft ready to mate with the payload.
Payload flight verification	9/01	8/01	-1 mos	Finish testing of the payload. Completed early
Final integration and test	8/02	8/02		Final testing of the integrated flight vehicle
Launch	10/02	10/02		

Lead Center: MSFC	**Other Centers:** KSC	**Interdependencies:** none
Subsystem	**Builder**	**Principal Investigator**
Spacecraft and Telescope:	Lockheed	
Dewar	Ball	
Payload	Stanford University	Francis Everett
Launch Vehicle:	**Tracking/Communications:**	**Data:**
Delta 2	Stanford	Stanford

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

Recent schedule progress has been very good, with most program milestones being completed on, or slightly ahead of, schedule. Still, schedule and budget reserves are minimal. The program is pressing to maintain the launch date, but a small slip (with some additional cost) is possible.

PROGRAM PLANS FOR FY 2003

Launch in October 2002. Operations will continue into FY 2004.

GP-B LIFE CYCLE COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	TOTAL
FY 2003 President's Budget	523.6	41.2	46.1	28.9	9.5	1.9				651.2
Development	475.8	39.6	44.8	13.8						574.0
Launch Services	47.8	1.6	1.3	5.9						56.6
Operations				2.0	1.0					3.0
Data Analysis				7.2	8.5	1.9				17.6
[Estimated Civil Servant FTE]		20	30	16	1	1				

BASIS OF FY 2003 FUNDING REQUIREMENT

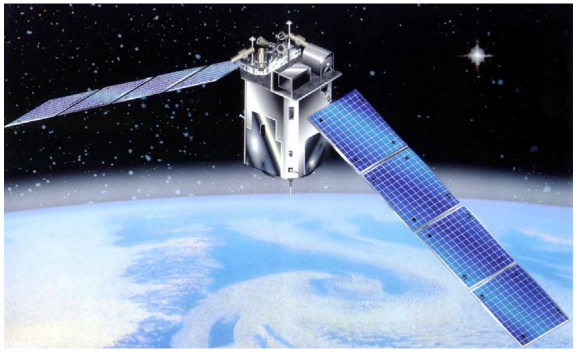
Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)

Web Address: http://www.timed.jhuapl.edu

	FY 2001	FY 2002	FY 2003
TIMED Development *	**13.3**	**4.2**	**--**

* TIMED total life cycle cost data is provided at the end of this section.

DESCRIPTION / JUSTIFICATION



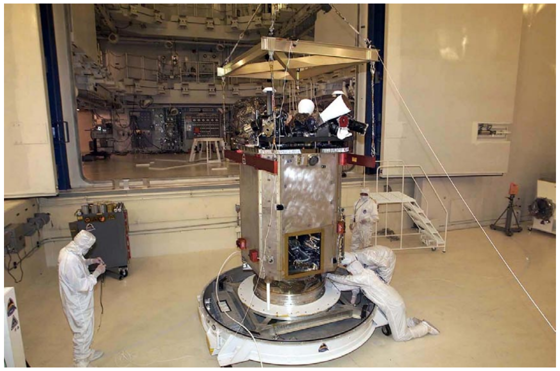
TIMED is the first mission the Solar Terrestrial Probes (STP) Program as detailed in the Space Science Strategic Plan. The TIMED mission will investigate the influences of the Sun and humans on the Mesosphere and Lower Thermosphere/Ionosphere (MLTI) regions of the Earth's atmosphere (60-180 km altitude), a gateway between Earth's environment and space. This region is where energetic solar radiation is absorbed, energy input from the aurorae (Northern and Southern Lights) is maximized, intense electric currents flow, and atmospheric waves and tides occur.

TIMED will provide a core subset of measurements defining the basic states (density, pressure, temperature, winds) of the MLTI region and its thermal balance for the first time. These measurements will be important for developing an understanding of the basic processes involved in the energy distribution of this region, and the impact of natural and man-made variations.

An understanding of the atmospheric variability of this region is vital so that the impact of these changes on satellite tracking, spacecraft lifetimes, degradation of spacecraft materials, and re-entry of piloted vehicles can be predicted. The mesosphere may also show evidence of man-made effects that could herald global-scale environmental changes.

TIMED ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	TIMED APPROACH
How do the earth and planets respond to the variability of the sun?	To understand the MLTI region's basic pressure, temperature and winds that result from the transfer of energy into and out of this region.



While these scientific objectives drive the mission design, TIMED has the potential to address a wide range of other atmospheric investigations. TIMED should be able to achieve many of the initial goals of the Sun-Earth Connection program; TIMED measurements of the MLTI region will provide future Sun-Earth Connection missions with a baseline for future investigations of global change.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand our changing Sun and its effects throughout the Solar System.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S7, "Earn external review rating of "green," on average, on making progress in the following research focus area:

- Understand the space environment of Earth and other planets."

Milestones	FY 2002 Budget Date	FY 2003 Budget Date	Change	Comment
Launch	8/01	12/01	+4 mos	Launch slip due to technical problems encountered by the co-manifested Jason 1 spacecraft; successful launch.

Lead Center: GSFC	**Other Centers:** LARC	**Interdependencies:** none.
Subsystem	**Builder**	
Spacecraft	Johns Hopkins University Applied Physics Laboratory (APL), Maryland	
Instruments	**Builder**	**Principle Investigator**
Solar EUV Experiment (SEE)	University Of Colorado	Woods
Sounding of the Atmosphere Board & Emission Radiometer (SABER)	Hampton University	Russell
Global Ultraviolet Imager (GUVI)	Aerospace/APL	Christensen
TIMED Doppler Interferometer (TIDI)	National Center for Atmospheric Research	Killeen
Launch Vehicle:	**Tracking/Communications:**	**Data:**
Delta II 7920-10	APL Satellite Control Facility	APL

PROGRAM PLANS FOR FY 2002

TIMED launched successfully on December 7, 2001.

TIMED LIFE CYCLE COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	TOTAL
FY 2003 President's Budget	176.0	14.9	16.4	10.0	7.0	6.6	2.5		233.4
Development	144.8	13.3	4.2						162.3
Launch Services	30.7								30.7
Operations		0.1	3.5	3.1					6.7
Data Analysis	0.5	1.5	8.7	6.9	7.0	6.6	2.5		33.7
[Estimated Civil Servant FTE]		6	2	3	3	3	3		

BASIS OF FY 2003 FUNDING REQUIREMENT

Stratospheric Observatory for Infrared Astronomy (SOFIA)

Web Address: http://sofia.arc.nasa.gov

	FY 2001	FY 2002	FY 2003
SOFIA Development *	**43.1**	**38.0**	**46.9**

* SOFIA out-year cost data is provided at the end of this section.

DESCRIPTION / JUSTIFICATION

Astronomical research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. For relatively low cost, NASA airborne systems have been able to provide to the science community very quick, global response to astronomical "targets of opportunity." SOFIA consists of a 2.5 m telescope, provided by the German Aerospace Center (DLR), integrated into a modified Boeing 747 aircraft.

The primary objective of the SOFIA program is to make fundamental scientific discoveries and contribute to our understanding of the universe through gathering and rigorous analysis and distribution of unique infrared astrophysical data. This objective will be accomplished by extending the range of astrophysical observations significantly beyond that of previous infrared airborne observatories, through increases in sensitivity and resolution.

While accomplishing its scientific mission, the SOFIA program will actively support our nation's goals to reform science, mathematics, and technology education, particularly at the K-12 level, and the general elevation of scientific and technological literacy throughout the country. In addition, the SOFIA program will identify, develop, and infuse promising new technologies.

The SOFIA aircraft; the primary telescope mirror

SOFIA will gather unique infrared astronomical data by flying above much of the moisture in the Earth's atmosphere, which absorbs many critical wavelengths. It will also be able to respond quickly to short-lived astronomical events, and offers a great deal of flexibility to the scientific community through the availability of several scientific instruments.

<u>LINKAGES TO STRATEGIC AND PERFORMANCE PLANS</u>

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate; learn how galaxies, stars, and planets form, interact and evolve; and understand the formation and evolution of the Solar System and Earth within it.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."

When operational, SOFIA will support APG #3S1, "Earn external review rating of "green," on average, on making progress in the following research focus area:

- Identify dark matter and learn how it shapes galaxies and systems of galaxies
- Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms.
- Observe the formation of planetary systems and characterize their properties
- Inventory and characterize the remnants of the original material from which the Solar System formed."

Milestones	FY 2002 Budget Date	FY 2003 Budget Date	Change	Comment
Complete bulkhead installation	FY 02	3Q/FY02		
Complete 747 structural mods	Under review	1Q/FY03		
Install cavity door on mockup	Under review	n/a	Deleted	Door will be installed directly on plane
First science flight	TBD	2005		

Lead Center: Ames **Other Centers:** GSFC (science instruments) **Interdependencies:** Germany

Prime contractor:	United Space Research Associates (USRA)
Subsystem	**Builder**
Aircraft: mods	Raytheon, Waco TX (USRA subcontract)
Aircraft operations	United Airlines (USRA subcontract)
Telescope	Germany

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

Aircraft modifications are proceeding well and will continue through FY 2002. In addition, delivery of the telescope from Germany is expected in FY 2002.

PROGRAM PLANS FOR FY 2003

During FY 2003, the aircraft door structural modifications will be completed, and the telescope will be installed. Development of science instruments will continue.

SOFIA COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	TOTAL
FY 2003 President's Budget	190.3	43.1	38.0	46.9	41.3	38.8	42.8	44.3		
Development	190.3	43.1	38.0	46.9	41.3					359.6
Operations						23.2	26.3	27.4	Cont.	
Data Analysis						15.6	16.5	16.9	Cont.	
[Estimated Civil Servant FTE]		68	58	45	43	41	41	41		

BASIS OF FY 2003 FUNDING REQUIREMENT

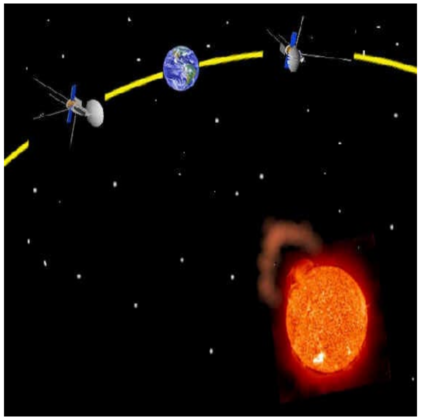
Solar Terrestrial Relations Observatory (STEREO)

Web Address: http://stp.gsfc.nasa.gov/missions/stereo/stereo.htm

	FY 2001	FY 2002	FY 2003
STEREO Development *	**[21.9]**	**52.9**	**74.3**

* STEREO Total life cycle cost data is provided at the end of this section.

DESCRIPTION / JUSTIFICATION

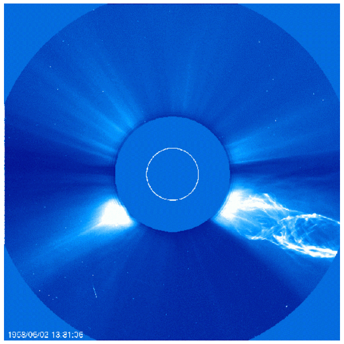
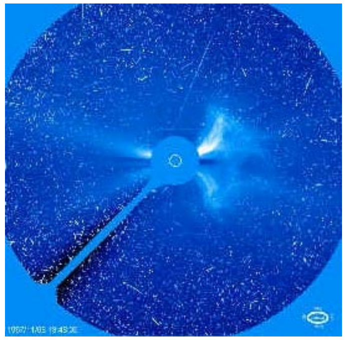


STEREO is the third mission planned in the Solar Terrestrial Probes (STP) program, as detailed in the Space Science Strategic Plan. STEREO's primary goal is to advance the understanding of the three-dimensional structure of the Sun's corona (outer "atmosphere"), the origin of huge eruptions of solar material known as coronal mass ejections (CMEs), their evolution in interplanetary space, and the interaction between CMEs and the earth's environment. STEREO will for the first time unveil the Sun in three dimensions. This will be achieved by:

- Sending two identically instrumented spacecrafts into solar orbits, with one flying ahead of the Earth and one behind.
- Measuring physical characteristics of CMEs with remote sensing and in-situ instruments.

STEREO ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	STEREO APPROACH
How and why does the Sun vary?	Make three-dimensional observations of CMEs from their origins out into the heliosphere for improved understanding of the physics involved, and for improved reliability of space weather forecasts and warnings.

These two images from the SOHO spacecraft show (left) helical structure in a CME that was not directed at Earth, and (right) a CME that was directed at Earth, creating a "blizzard" of solar protons. By observing the Sun from two different angles, STEREO will improve our understanding of Coronal Mass Ejections.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand our changing Sun and its effects throughout the Solar System.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."

When operational, STEREO will support APG #3S7, "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Understand the origins of long- and short-term solar variability.
- Understand the space environment of Earth and other planets.

and APG #3S8, "Earn external review rating of "green," on average, on making progress in the following research focus area:

- Develop the capability to predict space weather.

Milestones	**FY 2002 Budget Date**	**FY 2003 Budget Date**	**Change**	**Comment**
Start Phase C/D	FY 02	03/02		
Launch	12/04	12/05	+12 mos	cost/schedule reassessment and risk reduction

Lead Center: GSFC	**Other Centers:** KSC	**Interdependencies:**
Subsystem	**Builder**	Germany (DLR), United Kingdom (PPARC), France (CNES), Hungarian Space Office, University of Bern (Switzerland), European Space Agency
Spacecraft	JHU Applied Physics Laboratory	
Instruments	**Builder**	**Pr. Investigator**
SECCHI	Naval Research Laboratory	Howard
IMPACTS	University of California @ Berkeley	Luhmann
PLASTIC	University of New Hampshire	Galvin
S/WAVES	CNRS Observatory of Paris	Bougeret
Launch Vehicle:	**Tracking/Communications:**	**Data:**
Delta II 2925-10L	Deep Space Network	APL

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

STEREO expects to complete preliminary design reviews and independent assessments, before its planned March 2002 Confirmation Review. If approved to proceed, STEREO will begin the initial phase of implementation or Phase C. At that point detailed design of spacecraft and instrument systems and procurement of long lead parts will continue through the year.

PROGRAM PLANS FOR FY 2003

Design work will lead up to the Mission Critical Design Review. Flight component builds will continue through the remainder of the fiscal year.

STEREO LIFE CYCLE COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	TOTAL
FY 2003 President's Budget	15.0	21.9	52.9	74.3	90.0	61.2	36.5	23.1	17.3	392.2
Pre-Development	15.0	21.9	21.0							57.9
Development			31.9	64.4	62.5	34.4	16.5			209.7
Launch Services				9.9	27.5	26.8	4.2			68.4
Operations							7.4	9.4	4.7	21.5
Data Analysis							8.4	13.7	12.6	34.7
[Estimated Civil Servant FTE]		15	16	16	14	14	10	3		

BASIS OF FY 2003 FUNDING REQUIREMENT

Gamma-ray Large Area Space Telescope (GLAST)

Web Address: http://glast.gsfc.nasa.gov

	FY 2001	FY 2002	FY 2003
GLAST Development *	**[7.7]**	**20.7**	**69.2**

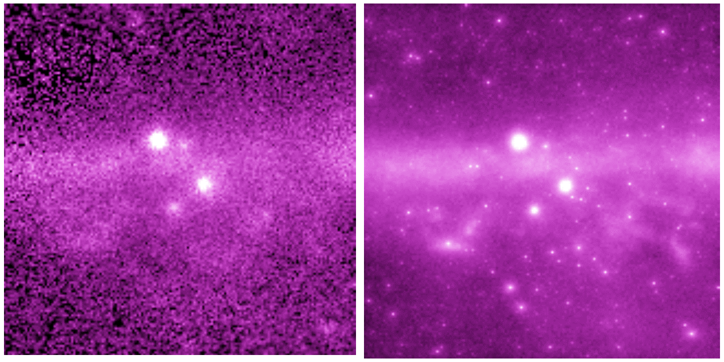
* GLAST Total life cycle cost data is provided at the end of this section.

DESCRIPTION / JUSTIFICATION

The Universe is home to numerous exotic and beautiful phenomena, some of which can generate almost inconceivable amounts of energy. Supermassive black holes, merging neutron stars, and streams of hot gas moving close to the speed of light are but a few of the marvels that generate gamma-ray radiation, the most energetic form of radiation, billions of times more energetic than the type of light visible to our eyes. What is happening to produce this much energy? What happens to the surrounding environment near these phenomena? Can understanding how the physical laws of the Universe operate in the extreme heat and pressure of these environments lead to new insights into how the Universe is structured and behaves?

The Gamma-ray Large Area Space Telescope (GLAST) will open this high-energy world to exploration and help us to answer these questions. With GLAST, astronomers will at long last have a superior tool to study how black holes, notorious for pulling matter in, can accelerate jets of gas outward at fantastic speeds. Physicists will be able to study subatomic particles at energies far greater than those seen in ground-based particle accelerators. And cosmologists will gain valuable information about the birth and early evolution of the Universe.

Views of the Galactic Anticenter comparing actual observations from NASA's Compton Gamma-Ray Observatory (CGRO, 1991-2000) with a GLAST simulation. GLAST's higher resolution and sensitivity will reveal many more stars and galaxies, in much greater detail, and will help answer numerous scientific riddles.



GLAST ANSWERS PRIMARY SCIENTIFIC QUESTIONS

SCIENTIFIC QUESTION:	GLAST APPROACH
What is happening at the centers of active galaxies?	GLAST will increase the number of known Active Galactic Nuclei (AGN) galaxies from about 70 to thousands, and will scan the sky every three hours for AGN flares.
What are the known gamma-ray sources that are still unidentified?	GLAST will enable identification of the more than 60% of CGRO sources that are still unidentified at other wavelengths, by greatly improving knowledge of each object's location.
Do our theories of particle physics need revision?	The large area and low instrument noise of GLAST will allow searches for exotic particle decay in the early Universe, and other evidence for elementary particles that have been postulated but not yet been detected.
When did most of the stars in the Universe form?	GLAST studies of the gamma-ray background radiation will relate directly to the star formation history of the Universe.
What causes gamma ray bursts?	GLAST will continue the recent revolution of gamma-ray burst understanding by measuring spectra and tracking afterglows. GLAST will make definitive measurements of the high-energy behavior of bursts that will not be superseded by any planned mission.
How do pulsars work?	GLAST will increase the number of known gamma-ray pulsars from seven to perhaps 250 or more, and will determine how such pulsars generate gamma rays and accelerate particles.
Where do cosmic rays come from?	GLAST will study supernova remnants and nearby galaxies to test theories of how cosmic rays (subatomic particles traveling near the speed of light) are produced.
How does the sun produce gamma rays?	GLAST will have unique high-energy capability for the study of solar flares, and will be the only mission observing high-energy photons from flares during the next solar maximum.

While these scientific objectives drive the mission design, GLAST's powerful capabilities have the potential to address a wide range of other astronomical investigations.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate; and explore the ultimate limits of gravity and energy in the Universe.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, “Earn external review rating of “green,” on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.”
When operational, GLAST will support APG #3S1, “Earn external review rating of “green,” on average, on making progress in the following research focus area:

- Identify dark matter and learn how it shapes galaxies and systems of galaxies.”

and APG #3S2, “Earn external review rating of “green,” on average, on making progress in the following research focus areas:

- Discover the sources of gamma ray bursts and high-energy cosmic rays.
- Reveal the nature of cosmic jets and relativistic flows.”

Milestones	FY 2002 Budget Date	FY 2003 Budget Date	Change	Comment
LAT PDR	FY 02	January 2002		Preliminary Design Review of the Large Area Telescope completed.
CDR	N/A	3Q/FY03		
Launch	N/A	FY 06		

Lead Center: GSFC	**Other Centers:** MSFC	**Interdependencies:** DOE, France, Germany, Japan, Italy, Sweden
Instruments Large Area Telescope GLAST Burst Monitor	**Builder** Stanford Linear Accelerator Center MSFC	**Pr. Investigator** Stanford University Dr. Charles Meegan, MSFC
Launch Vehicle: Medium class	**Tracking/Communications:** Italy	**Data:** High Energy Astrophysics Science Archive Research Center (HEASARC)

PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

GLAST is scheduled for Phase C/D Confirmation in FY 2002. If approved to proceed, the implementation phase will begin at that point. Spacecraft contractor selection is scheduled for the third quarter of FY 2002. Detailed instrument design work will lead to Instrument Critical Design Reviews in late FY 2002 and early FY 2003.

PROGRAM PLANS FOR FY 2003

Detailed spacecraft design work will continue, leading to spacecraft Critical Design Review in late FY 2003.

GLAST LIFE CYCLE COST DATA ($ in millions)

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	TOTAL
FY 2003 President's Budget	4.9	7.7	20.7	69.2	106.7	75.0	43.4	20.2	161.8	509.6
Pre-Development	4.9	7.7	8.2							20.8
Development			12.5	69.2	74.6	47.3	23.4			227.0
Launch Services					32.1	27.7	10.9			70.7
Operations							2.5	4.7	33.2	40.4
Data Analysis							6.6	15.5	128.6	150.7
[Estimated Civil Service FTE]	10	30	42	42	37	37	28	9		

BASIS OF FY 2003 FUNDING REQUIREMENT

New Frontiers Program

	FY 2001	FY 2002	FY 2003
New Frontiers Program	--	--	15.0

DESCRIPTION / JUSTIFICATION

New Frontiers is a revamping of the Outer Planets missions program. New Frontiers will pursue a clear set of goals and science priorities with an emphasis on understanding the origins of life and the potential for life elsewhere in the Solar System, and will select missions through a fully open and competitive process. It is envisioned that New Frontiers will be structured and managed along the lines of the highly successful Discovery program. The program will provide frequent access to space for mid-sized planetary missions that will perform high-quality scientific investigations. New Frontiers responds to the need for multiple missions of varying costs for solar systems and will seek to balance science return in this decade with investments that will enable more frequent missions with shortened development and trip times and more science return per dollar.

There will be close coupling between this new program and new technologies developed in the Nuclear Power, Nuclear Propulsion and In-Space Propulsion programs. Missions will be selected through open, peer-reviewed competitions subject to rigorous cost/schedule/risk reviews. The cost of building, launching, and operating a New Frontiers mission must not exceed $650 million in FY 2003 dollars and the mission must launch within 48 months from start of development.

The first Announcement of Opportunity is planned for release in spring 2002 with the science priorities responsive to the results of the Solar System Exploration Decadal Survey. Like the Discovery program, New Frontiers will also allow for selection of Missions of Opportunity. Missions of Opportunity involve participation in a non-NASA mission, typically sponsored by non-U.S. governments, other U.S. government agencies, or private sector organizations. This participation could include providing a complete science instrument, hardware components of a science instrument, or expertise in critical areas of the mission.

BASIS OF FY 2003 FUNDING REQUIREMENT

Payload and Instrument Development

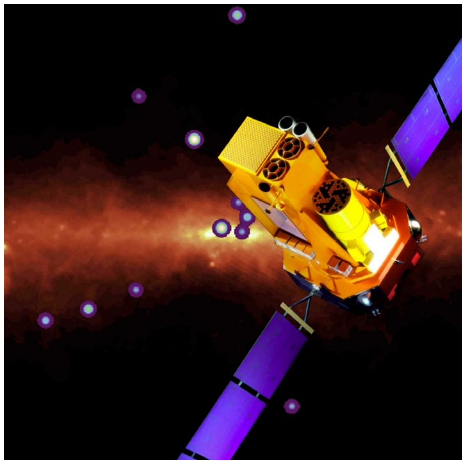
	FY 2001	FY 2002	FY 2003
International Gamma Ray Astrophysics Laboratory (INTEGRAL)	1.4	1.3	0.5
Rosetta	7.7	1.3	0.9
Solar-B	22.1	25.4	16.2
Herschel		14.6	15.4
Planck	7.9	4.8	4.9
Other Payload and Instrument Development	0.5	0.1	0.1
Total	**39.6**	**47.5**	**38.0**

DESCRIPTION / JUSTIFICATION

Payload and Instrument Development supports the development of hardware to be used on international satellites or on Shuttle missions. International collaborative programs offer opportunities to leverage U.S. investments, and thus to obtain scientific data at a relatively low cost. Shuttle missions utilize the unique capabilities of the Shuttle to perform scientific experiments that do not require the extended operations provided by free-flying spacecraft.

The five international payloads currently under development (INTEGRAL, Rosetta, Solar-B, Herschel, and Planck) are described on the following pages. Other Payload and Instrument Development funding supports project management of the Spartan free-flying platform at GSFC (terminated in FY 2001) and project management activities at the Jet Propulsion Laboratory.

International Gamma Ray Astrophysics Laboratory (INTEGRAL) http://sci.esa.int/home/integral/index.cfm



INTEGRAL is a European Space Agency mission, with Russian and U.S. involvement. U.S. participation consists of co-investigators providing hardware and software components to the spectrometer and imager instruments; a co-investigator for the data center; a mission scientist; and a provision for ground tracking and data collection.

Objectives:

- Perform detailed spectroscopic and imaging studies of objects initially explored by the Compton Gamma Ray Observatory.
- Investigate processes taking place under extreme conditions of density, temperature, and magnetic field.

Funding:

FY 2001	FY 2002	FY 2003
1.4	1.3	0.5

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
Launch	n/a	10/02	Date set by ESA

Rosetta ***http://sci.esa.int/home/rosetta/index.cfm***

Rosetta is a European Space Agency comet mission that will be launched in January 2003. After a long cruise phase, the satellite will rendezvous with comet Wirtanen in 2011 and orbit it, while taking scientific measurements. A Surface Science Package will land on the comet surface to take in-situ measurements. The U.S. is developing three remote sensing instruments and a subsystem for a fourth instrument.

Objectives:

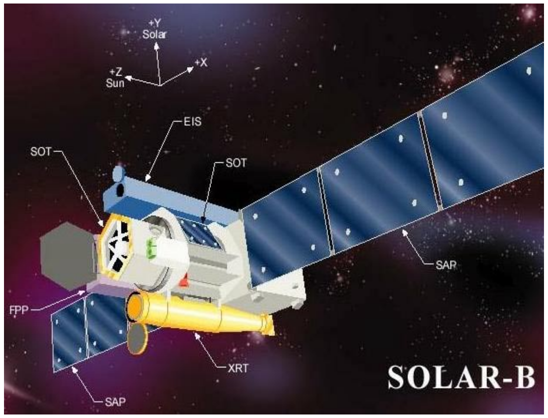
- Study the origin of comets
- Study the relationship between cometary and interstellar material
- Improve our knowledge of the origins of the Solar System

Funding:

FY 2001	FY 2002	FY 2003
7.7	1.3	0.9

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
U.S. Flight Unit Deliveries	3rd Qtr FY 01	3rd Qtr FY 01	Completed
Launch	January 2003	January 2003	Set by ESA

Solar-B ***http://stp.gsfc.nasa.gov/missions/solar-b/solar-b.htm***



Solar-B is a Japanese Institute of Space and Astronautical Science (ISAS) mission, with significant U.S. involvement, and follows the highly successful Japan/US/UK Yohkoh (Solar-A) collaboration. The mission consists of a coordinated set of optical, EUV and X-ray instruments. NASA will provide the Focal Plane Package for the optical telescope and components of the X-ray telescope and the Extreme Ultraviolet Imaging Spectrometer (EIS).

Objectives:

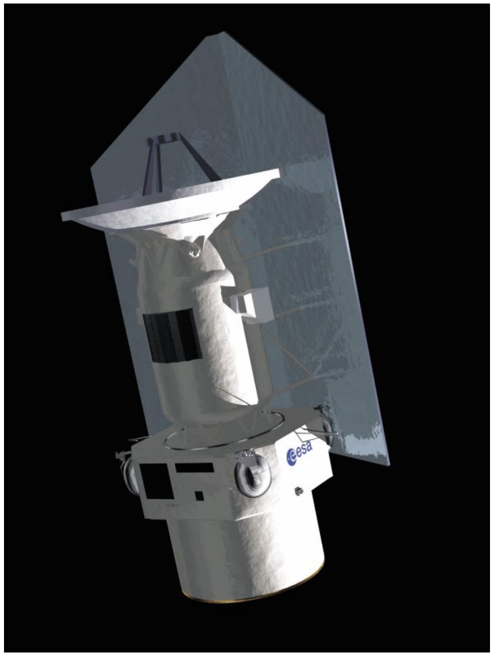
- Investigate the interaction between the Sun's magnetic field and its corona
- Understand the sources of solar variability

Funding:

FY 2001	FY 2002	FY 2003
22.1	25.4	16.2

Key Milestones:	**FY 2002 Budget Date**	**FY 2003 Budget Date**	**Comment**
EIS Pre-Environmental Review	FY 02	1/02	EIS instrument ready for environmental testing
Instrument Delivery	n/a	FY 04	3 instruments – date refers to last instrument delivery
Launch	n/a	FY 05	Launch readiness date is established by ISAS

Herschel ***http://sci.esa.int/home/first/index.cfm***



ESA's Herschel Space Observatory (formerly called Far Infrared and Submillimetre Telescope or FIRST) is an infrared telescope that will observe at wavelengths never covered before. Herschel is the fourth Cornerstone Mission (CS4) in the European Space Agency's "Horizon 2000" science plan. It will open up a virtually unexplored part of the spectrum that cannot be observed well from the ground. NASA is providing components for two of the three instruments that will be flown on Herschel: the Heterodyne Instrument for Far Infrared (HIFI) and the Spectral and Photometric Imaging Receiver (SPIRE).

Objectives:

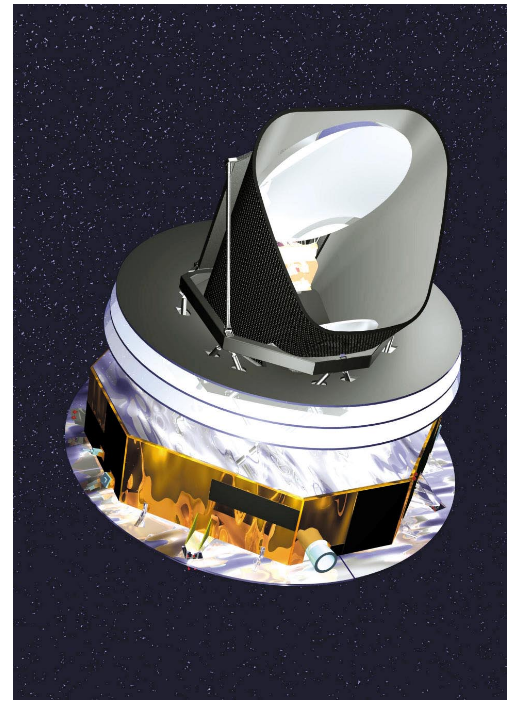
- Understand galaxy formation and evolution in the early universe, and the nature of active galaxy power sources
- Understand star forming regions and interstellar medium physics in the Milky Way and other galaxies
- Understand the molecular chemistry of cometary, planetary and satellite atmospheres in our solar system

Funding:

FY 2001	FY 2002	FY 2003
	14.6	15.4

Key Milestones:	**FY 2002 Budget Date**	**FY 2003 Budget Date**	**Comment**
Frequency mixer demonstrated	FY 01	June 2001	Completed on time
SPIRE qual. model detectors	FY 02		
Launch	n/a	2007	Launch date set by ESA

Planck ***http://sci.esa.int/home/planck/index.cfm***



Planck is the third Medium-Sized Mission (M3) of the European Space Agency's Horizon 2000 Scientific Programme. It is designed to image minor variations in the Cosmic Background Radiation over the whole sky, with unprecedented sensitivity and angular resolution. In support of the Planck mission, NASA is providing two redundant cryocoolers for the spacecraft and components for the High Frequency Instrument (HFI), one of the two instruments that will be flown on Planck.

Objectives:

- Will the Universe continue its expansion forever?
- What is the age of the Universe?
- What is the total amount of matter in the Universe and what is this matter made of?

Funding:

FY 2001	FY 2002	FY 2003
7.9	4.8	4.9

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
Cooler Test	FY 01	September 2000	completed
Cooler performance report	4th Qtr FY01	September 2001	completed
HFI Flight detectors complete	FY 02	1Q/FY03	
Launch	n/a	2007	Launch date set by ESA

BASIS OF FY 2003 FUNDING REQUIREMENT

Explorers Program

Web Address: http://explorers.gsfc.nasa.gov/missions.html

	FY 2001	FY 2002	FY 2003
Microwave Anisotropy Probe (MAP) *	17.7		
Swift Gamma Ray Burst *	50.1	57.0	33.5
Full-Sky Astrometric Mapping Explorer (FAME) *	20.0		
Small Explorers (SMEX)	37.0	38.5	3.7
Explorer Planning (All Others)	16.5	29.7	97.9
Total	**141.3**	**125.2**	**135.1**

* Total life cycle cost data is provided at the end of each section.

DESCRIPTION / JUSTIFICATION

The mission of the Explorers Program is to provide frequent flight opportunities for world-class astrophysics and space physics investigations utilizing innovative, streamlined and efficient management approaches to spacecraft development and operations. The program also seeks to enhance public awareness of, and appreciation for, space science and to incorporate educational and public outreach activities as integral parts of space science investigations.

Explorer missions are categorized by size, starting with the largest, the Medium-class (MIDEX) missions launched by Delta Expendable Launch Vehicles (ELVs), and the Small-class (SMEX) missions launched on Pegasus-class. Also included in both the MIDEX and SMEX mission classes are Missions of Opportunity (MO). MOs have a total NASA cost of under $35 million. These missions are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission.

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planets, and life.

Strategic Plan Objectives Supported: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate; explore the ultimate limits of gravity and energy in the Universe; and learn how galaxies, stars, and planets form, interact and evolve.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."

Microwave Anisotropy Probe (MAP) ***http://map.gsfc.nasa.gov/***

Objective: The Cosmic Microwave Background Explorer (COBE) was the first spacecraft to map the cosmic background radiation, providing strong confirmation of the Big Bang. The Microwave Anisotropy Probe (MAP) will make a map of the temperature fluctuations of the cosmic microwave background radiation with much higher resolution, sensitivity, and accuracy than COBE. The new information contained in these finer fluctuations will shed light on several key questions in cosmology, including the geometry of the universe, the amount of dark matter in the universe, and the origin of structures of galaxies in the early universe.

Salient Features:
Lead Center and Spacecraft: GSFC
Principal Investigator: Charles Bennett, GSFC
Launch vehicle: Delta 2
L2 Orbit, 3 years prime mission life

MAP Life Cycle Cost Data ($ in millions)

	Prior	FY01	FY02	FY03	FY04	FY05	FY06	FY07	BTC	Total
FY 2003 President's Budget	126.5	22.1	3.7	4.7	1.6					158.6
Development	82.9	11.3								94.2
Launch Vehicle	43.6	6.4								50.0
Mission Operations		1.5	1.8	1.4						4.7
Data Analysis		2.9	1.9	3.3	1.6					9.7

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
Launch	3rd Qtr FY01	June 30, 2001	Launched successfully

Swift Gamma-Ray Burst ***http://swift.gsfc.nasa.gov/***

Objective: Swift will determine redshifts for most of the bursts that it detects (allowing us to know how far away they are and how absolutely bright they are), and will also provide detailed multi-wavelength light curves for the duration of the afterglow (allowing us to probe the physical environment in which the event took place). Studying ~ 500 bursts in its two-year nominal mission, Swift has the capability to determine the origin of the still-mysterious gamma-ray bursts, and to use them to probe the conditions that existed in the early Universe. Swift is the first mission to focus on studying the afterglow from gamma ray bursts.

- Lead Center: GSFC
- Spacecraft: Spectrum Astro
- Science Instruments:
  Burst Alert Telescope (BAT) - GSFC
  X-ray Telescope (XRT) - Penn State
  UltraViolet/Optical Telescope (UVOT) - Penn State
- Launch vehicle: Delta 2
- Low-Earth Orbit; 3 year prime mission

Swift Life Cycle Cost Data ($ in millions)

	Prior	FY01	FY02	FY03	FY04	FY05	FY06	FY07	BTC	Total
FY 2003 President's Budget	22.2	50.1	57.0	33.5	3.9	3.0	2.6			172.3
Development	22.2	36.5	37.2	17.0						112.9
Launch Vehicle		13.6	19.8	16.5						49.9
Mission Operations					2.6	1.9	1.6			6.1
Data Analysis					1.3	1.1	1.0			3.4

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
Spacecraft subsystems complete	FY 02	9/02	
Start S/C Level I&T	n/a	9/02	Milestone not established in the FY 2002 budget
Launch	n/a	9/03	Milestone not established in the FY 2002 budget

Full Sky Astrometric Mapping Explorer (FAME) ***http://www.usno.navy.mil/FAME/***

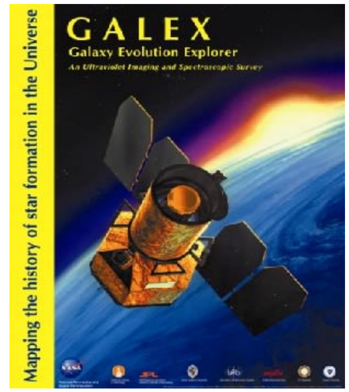
Objective: FAME was planned as an astrometric satellite designed to determine with unprecedented accuracy the positions, distances, and motions of 40 million stars within our galactic neighborhood. It was a collaborative effort between the U.S. Naval Observatory (USNO) and several other institutions. FAME was designed to measure stellar positions to less than 50 microarcseconds. The mission was not approved to proceed to development in early FY 2002, due to unacceptable cost growth identified at the Confirmation Review.

FAME Cost Data ($ in millions)

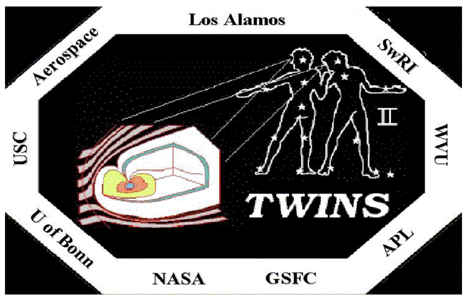
	Prior	FY01	FY02	FY03	FY04	FY05	FY06	FY07
Pre-development	5.2	20.0						

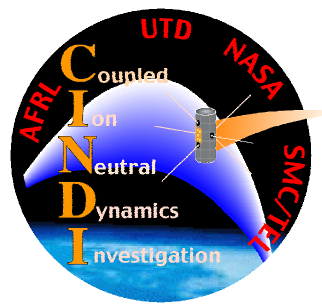
Small Explorers Program (SMEX) *http://explorers.gsfc.nasa.gov/missions.html*

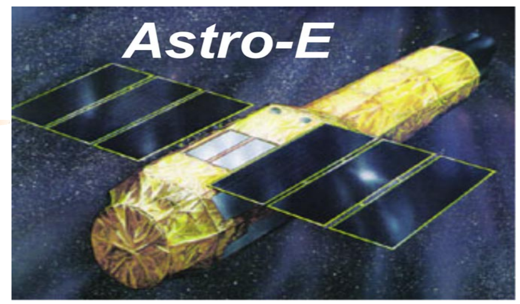
The Small Explorer (SMEX) program provides frequent flight opportunities for highly focused and relatively inexpensive missions. SMEX investigations are characterized by a total cost to NASA for definition, development, launch service, and mission operations and data analysis not to exceed $85 million (in Fiscal Year 2002 dollars). It is NASA's goal to launch one Small Explorer mission per year and one Mission of Opportunity per year.



Missions of Opportunity (MO) are space science investigations, costing no more than $35 million in FY 2002 dollars that are flown as part of a non-NASA space mission. MO are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. OSS intends to solicit proposals for MO with all future Explorer Announcements of Opportunities.







MISSIONS	LAUNCH DATE	OBJECTIVES
HESSI (High Energy Solar Spectroscopic Imager)	January 2002	explore the physics of particle acceleration and explosive energy release in solar flares
GALEX (The Galaxy Evolution Explorer)	May 2002	map the history and probe the causes of star formation and its evolution.
CINDI (MO) (Coupled Ion Neutral Dynamics Investigation)	Late 2003	provide measurements of the neutral atmosphere wind velocity and the charged particle drifts in the equatorial upper atmosphere at altitudes from 400 to 700 km.
TWINS A/B (MO) (Two Wide-angle Imaging Neutral-atom Spectrometers)	2003, 2005	stereoscopically image the magnetosphere
ASTRO-E2 (MO)	2005	Japanese x-ray astronomy mission to study high-energy phenomena

Explorer Planning ***http://explorers.gsfc.nasa.gov/missions.html***

Explorer Planning supports development of the Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) mission. CHIPS is the last University-class Explorer (UNEX) mission, and will use an extreme ultraviolet spectrograph to study the "Local Bubble," a tenuous cloud of hot gas surrounding our solar system that extends about 300 light-years from the Sun. The University of California at Berkeley is developing CHIPS for a planned launch in August 2002; SpaceDev is building the CHIPS spacecraft.

Explorer planning also covers Explorer program management costs, the costs for soliciting and evaluating new missions, and the formulation and implementation costs for those new missions. In FY01, the Explorer program conducted funded concept studies for six potential SMEX missions and two potential MO missions. One of the MO missions was selected for flight (Astro-E2) in July 2001. An Announcement of Opportunity (AO) for the next two MIDEX missions was released in July 2001. In FY02, approximately four MIDEX projects, and possibly one or more MO projects, will be selected for funded concept studies (estimated date April 2002). Also, two of the six SMEX missions will be selected for flight and a decision will be made on the MO mission (estimated date July 2002). In FY03, development will begin on the two selected SMEX missions (estimated start October 2002), two of the MIDEX missions will be selected for flight and development will begin on them (estimated date January 2003), and an AO will be released for two future SMEX missions.

BASIS OF FY 2003 FUNDING REQUIREMENT

Discovery Program

Web Address: http://discovery.nasa.gov/

	FY 2001	FY 2002	FY 2003
Genesis Development *	22.0		
CONTOUR Development*	62.2	22.3	
MESSENGER Development *	51.8	94.3	68.0
Deep Impact Development *	72.7	85.2	59.1
Future Missions	4.3	12.8	80.6
Total	**213.0**	**214.6**	**207.7**

***** Total life cycle cost data is provided at the end of each section.

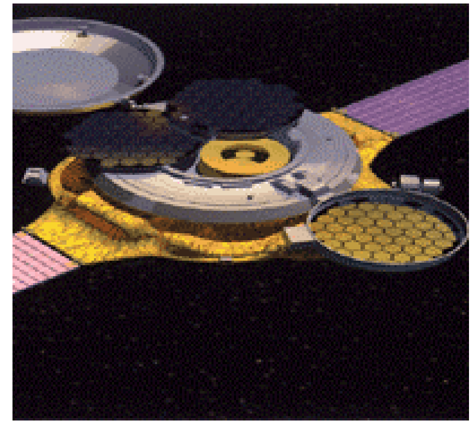
DESCRIPTION / JUSTIFICATION

The Discovery program provides frequent access to space for small planetary missions that perform high-quality scientific investigations. The program responds to the need for low-cost planetary missions with short development schedules. Emphasis is placed on increased management of the missions by principal investigators. Missions are selected through open, peer-reviewed competitions, to ensure science community involvement while enhancing the return on investment. The Discovery program also aids in the national goal to transfer technology to the private sector. The cost of building, launching, and operating a Discovery mission must not exceed $300 million in FY 2001 dollars, and the mission must launch within three years from start of development.

Genesis ***http://genesismission.jpl.nasa.gov/***

Objective: “To capture a piece of the Sun and return it to Earth” -- To provide a sample of the solar wind, helping answer fundamental questions about the exact composition of the Sun and the chemical diversity present at the birth of our solar system

Salient Features:
- Principal Investigator: Don Burnett, California Institute of Technology
- Lead Center: JPL
- Spacecraft: Lockheed Martin; Launch vehicle: Delta 2
- Orbit about the Sun-Earth L1 point
- Science Instruments: Collector Arrays and Concentrator
- 2 Enabling Instruments: Electron Monitor and Ion Monitor
- Launched August 8, 2001; Sample Return to Earth: September 2004
- Minimum Sample Collection Time Required: 22 Months



Science:
- Measure Elemental & Isotopic Abundance’s of Solar Wind Ions
- Provide a Reservoir of Solar Matter for Future Analysis

Genesis Life Cycle Cost Data:

	Prior	**FY 01**	**FY 02**	**FY 03**	**FY 04**	**FY 05**	**FY 06**	**FY 07**	**BTC**	**Total**
	189.7	29.6	10.2	10.0	9.3	3.0	1.9	1.1	0.2	255.0
Pre-development	11.5									11.5
Development	130.7	20.8								151.5
Launch Services	47.5	1.2								48.7
Operations		3.4	6.2	7.2	6.2	0.4				23.4
Data Analysis		4.2	4.0	2.8	3.1	2.6	1.9	1.1	0.2	19.9
[Est. Civil Servant FTE]		2	1	1	1	1	1	1		

Key Milestones:	**FY 2002 Budget Date**	**FY 2003 Budget Date**	**Comment**
Launch	7/01	8/01	Launched August 8, 2001; sample return September 2004

Comet Nucleus Tour (CONTOUR) ***http://www.contour2002.org/***

Objective: To dramatically improve our knowledge of comet nuclei and to assess their diversity

Salient Features:
- Will encounter and study at least two comets, using Earth-gravity assist maneuvers
- Science Instruments: a wide-angle imager (CFI), a high-resolution imager and spectral mapper (CRISP), a dust analyzer (CIDA) and a neutral gas/ion mass spectrometer (NGIMS)
- Principal Investigator: Joe Veverka, Cornell University
- Lead Center and Spacecraft: APL
- Launch date: July 2002 on a Delta 2 vehicle
- Comet Encke encounter – November 12, 2003
- Comet Schwassmann-Wachmann-3 encounter – June 19, 2006

Science:
- To measure the diversity of comets' nuclei
- To study from close range the dynamic processes that shape a comet's nucleus
- To assess the differences between Kuiper Belt and Oort Cloud comets

CONTOUR Life Cycle Cost Data:

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	Total
	61.3	62.2	22.3	3.9	3.5	1.8	3.4			158.4
Pre-development	9.2									9.2
Development	35.2	41.6	10.8							87.6
Launch services	16.9	20.6	11.5							49.0
Operations				2.4	2.0	0.4	1.6			6.4
Data Analysis				1.5	1.5	1.4	1.8			6.2
[Est. Civil Servant FTE]		10	9	6	6	3	3			

Key Milestones:	**FY 2002 Budget Date**	**FY 2003 Budget Date**	**Comment**
Complete environmental testing	FY 02	4/02	
Launch	7/02	7/02	On schedule

MESSENGER (MErcury Surface, Space ENvironment, Geochemistry, and Ranging) ***http://messenger.jhuapl.edu/***

Objective: To investigate key scientific questions regarding Mercury's characteristics and environment in order to better understand the evolution of terrestrial planets

Salient Features:
- Principal Investigator: Sean Solomon, Carnegie Institute of Washington
- Lead Center and Spacecraft: APL
- Seven miniaturized science instruments
- Launch date: March 2004, Delta 2 vehicle
- Five year voyage includes two flybys of Venus and two flybys of Mercury
- Enter Mercury orbit in April 2009 and orbit for one Earth year

Science: Answer the questions
- Why is Mercury so dense?
- What is the geologic history of Mercury?
- What is the structure of Mercury's core?
- What is the nature of Mercury's magnetic field?
- What are the unusual materials at Mercury's poles?
- What volatiles are important at Mercury?

MESSENGER Life Cycle Cost Data:

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	Total
	11.3	51.8	94.3	68.0	39.1	7.1	7.5	8.7	42.2	330.0
Pre-Development	11.1	20.3								31.4
Development		25.9	72.8	46.0	19.1					163.8
Launch Services	0.2	5.6	21.5	22.0	15.6					64.9
Operations					2.9	4.1	4.2	4.2	19.5	34.9
Data Analysis					1.5	3.0	3.3	4.5	22.7	35.0

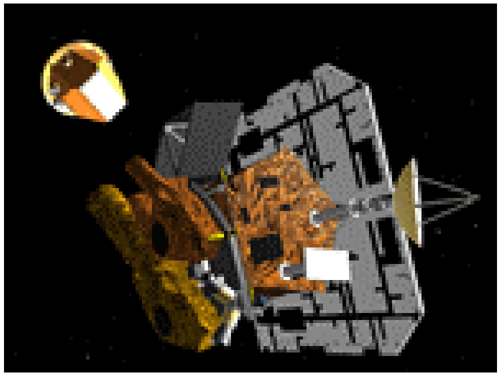
Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
Critical Design Review	FY 02	3/02	
Launch	3/04	3/04	On schedule

Deep Impact ***http://deepimpact.jpl.nasa.gov***

Objective: To study the pristine interior of a comet by excavating a crater approximately 25 m deep and 100 m in diameter

Salient Features:

- Two part spacecraft: a larger "flyby" spacecraft carrying a smaller "impactor" spacecraft
- Principal Investigator: Michael A'Hearn, University of Maryland
- Lead Center: JPL; Spacecraft: Ball Aerospace
- Launch: January 2004, Delta 2 vehicle; Impact: July 2005
- Impactor will crash into the surface of a comet nucleus at 22,000 miles per hour
- Camera on the impactor will capture and relay images of the comet nucleus just before it collides with the comet
- Flyby spacecraft will observe and record the impact
- Professional and amateur astronomers expected to observe the impact from Earth



Science Objectives:

- Dramatically improve the knowledge of key properties of cometary nuclei
- Measure the composition of the interior of the comet
- Improve our understanding of the evolution of cometary nuclei

Deep Impact Life Cycle Cost Data:

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	Total
	24.2	72.7	85.2	59.1	21.0	11.1	2.0			275.3
ATD	24.1	15.5								39.6
Development		49.9	62.7	36.3	7.7					156.6
Launch Services	0.1	7.3	22.5	22.8	4.9					57.6
Operations					6.8	8.2	0.3			15.3
Data Analysis					1.6	2.9	1.7			6.2

Key Milestones:	FY 2002 Budget Date	FY 2003 Budget Date	Comment
PDR	2/01	2/01	Held week of 2/26/01
CDR	1/02	1/02	On schedule
Launch	1/04	1/04	On schedule

Future Missions

Future Mission funding covers program management costs, costs for soliciting and evaluating new missions as well as costs for selected Missions of Opportunity. Missions of Opportunity involve participation in a non-NASA mission, typically sponsored by non-U.S. governments, other U.S. government agencies, or private sector organizations. This participation could include providing a complete science instrument, hardware components of a science instrument, or expertise in critical areas of the mission.

Selection of the next two Discovery missions was announced in December 2001. The selected missions are Dawn, which will orbit the two largest asteroids in our solar system, and Kepler, a space telescope that will search for Earth-like planets around nearby stars. Additional information about Dawn is available at http://www-ssc.igpp.ucla.edu/dawn/ , and Kepler is at http://www.kepler.arc.nasa.gov/

Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3) is the first Discovery Mission of Opportunity approved for implementation in October 1999. ASPERA-3 will provide parts of a scientific instrument to study the interaction between the solar wind and the atmosphere of Mars. It will fly aboard the European Space Agency's Mars Express spacecraft in 2003. http://discovery.nasa.gov/aspera.html

The second Discovery Mission of Opportunity is a French led-Mars mission, NetLander, approved for implementation in January 2001. The Discovery NetLander project will contribute key components of the payload to allow the delineation of the interior structure of Mars and characterize the behavior of its atmosphere. It will fly aboard the CNES PREMIER orbiter in 2007. http://www-projet.cst.cnes.fr:8060/NETLANDER/index.html

BASIS OF FY 2003 FUNDING REQUIREMENT

Mars Exploration Program (MEP)

Web Address: ***http://mars.jpl.nasa.gov/overview/index.html***

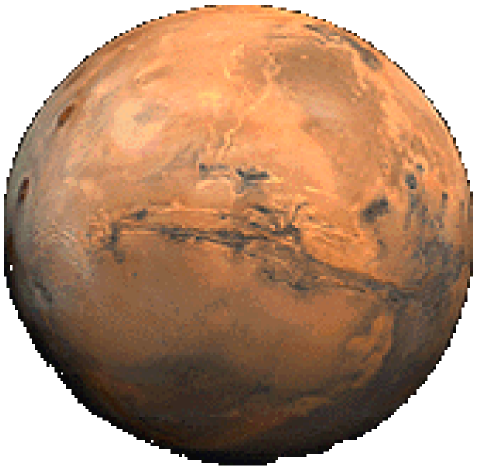
	FY 2001	FY 2002	FY 2003
2001 Mars Odyssey *	38.3		
2003 Mars Exploration Rovers (MER) *	296.0	245.2	113.9
Mars Express	6.8	3.8	3.4
2005 Mars Reconnaissance Orbiter (MRO) *	12.0	57.9	143.5
Future Mars **	76.5	88.4	176.3
JPL Flight Project Management Facility		19.4	16.5
TOTAL	**429.6**	**414.7**	**453.6**

* Total life cycle cost data is provided at the end of this section.
** Includes 2007 Mars Scout (fully competed mission); 2009 Mars Smart Lander/Mobile Laboratory; Mars International Missions; 34M Beam-Wave-Guide Antenna; Mars Technology; Planetary Protection; and Mars Program Management. See p. SAT 1-53

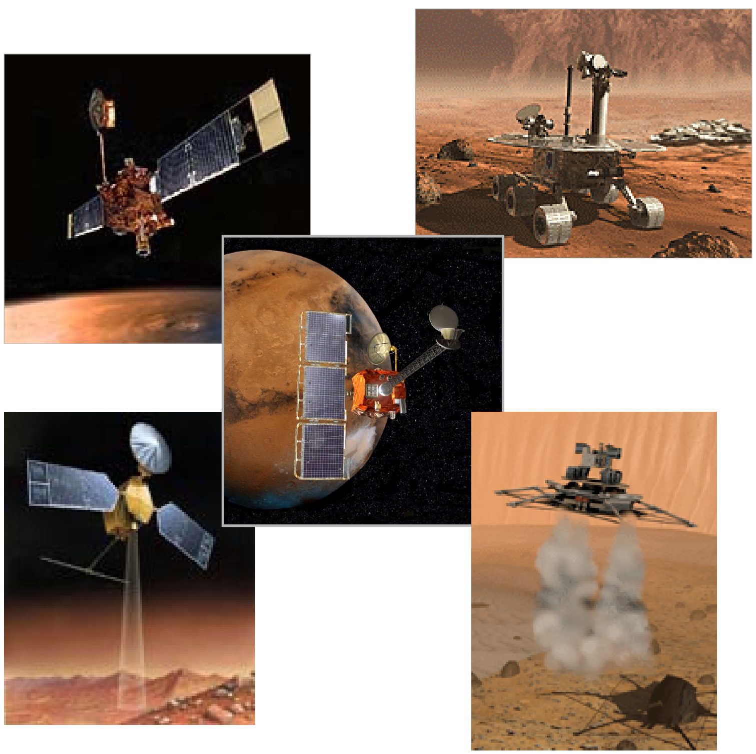
DESCRIPTION / JUSTIFICATION

The Mars Exploration Program (MEP) is an aggressive, sustained series of missions to Mars, to understand the planet's past and present conditions and their potential to support life. Taking advantage of launch opportunities available approximately every 26 months, the MEP science strategy is to "follow the water" in understanding the climatological, geological, and potentially biological history of Mars. In addition, these missions provide the scientific and technological basis for the next decade of Mars exploration.

Mars Exploration Program



A science-driven effort to characterize and understand Mars as a dynamic system, including its present and past environment, climate cycles, geology, and biological potential. A key question is whether life ever arose on Mars.



***Strategy:* "*Follow the Water*"**

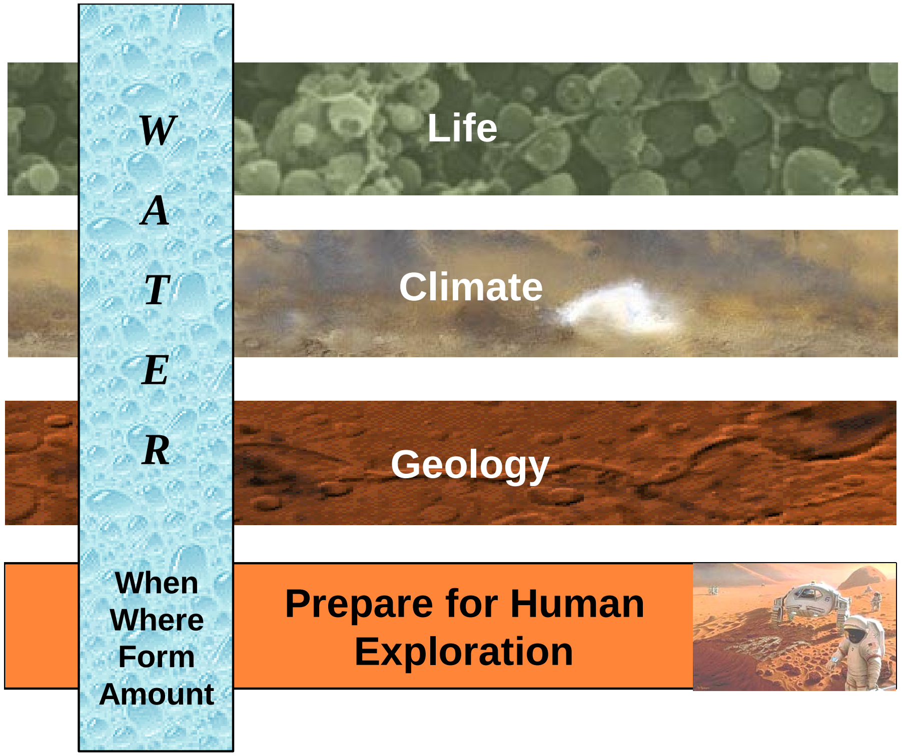
Search for sites on Mars with evidence of past or present water activity and with materials favorable for preserving either bio-signatures or life-hospitable environments

***Approach:* "*Seek - In Situ - Sample*"**

Orbiting and surface-based missions are interlinked to target the best sites for detailed analytic measurements and eventual sample return

Mars Science Strategy: "Follow the Water"

- When was it present on the surface?
- How much and for how long?
- Where did it go, and what are the telltale features it left behind?
- Did it persist long enough for life to have developed?



Understand the potential for life elsewhere in the Universe

Characterize the present and past climate and climate processes

Understand the geological processes affecting Mars' interior, crust, and surface

Develop knowledge and technology necessary for future human and robotic exploration

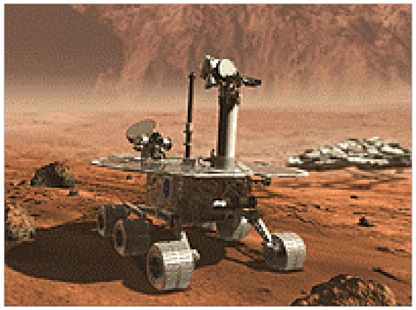
To achieve the goals as outlined above, these series of near-term Mars Exploration missions are required:

MEP Missions	Science Objectives
Mars Global Surveyor (MGS)	Mars Global Surveyor is currently orbiting Mars and mapping the planet at infrared and visible wavelengths and observing selected areas at high resolution.
2001 Mars Odyssey	2001 Mars Odyssey's objective is to determine the elemental and chemical composition of the Martian surface, map the mineralogy and morphology of the surface, and measure the radiation environment around Mars. The 2001 Mars Odyssey launched successfully April 2001, arrived at Mars in October 2001, and will start returning scientific data in February 2002.
2003 Mars Exploration Rovers (MER)	The goal of both rovers will be to learn about the history of ancient water and its role in the geology and climate of Mars. Each rover will be a robotic field geologist, equipped to read the geological record at its landing site and to learn what the conditions were like when the rocks and soils there were formed. The twin rovers will also have the mobility to travel up to 1000 meters across the Martian landscape, measuring the chemical character of the soils, rocks, and even the previously inaccessible interiors of rocks where unaltered materials may lurk.
Mars Express	Mars Express is a European Space Agency mission carrying US-provided instruments that will explore the atmosphere and surface of Mars from polar orbit. The mission's main objective is to search for sub-surface water from orbit and deliver a small lander to the Martian surface in 2003.
2005 Mars Reconnaissance Orbiter (MRO)	The goal of the orbiter is to understand the history of water on Mars by observing the planet's atmosphere, surface, and subsurface in unprecedented detail. This mission will identify the best sites for a new generation of landed vehicles to explore, by virtue of its ability to find local evidence of the chemical and geological "fingerprints" of water and other critical processes. MRO will explore from orbit several hundred locations on the surface of Mars, observing details that were previously only visible to landers. MRO will focus on the locations identified as most promising by MGS and Odyssey, searching for the most compelling environmental indicators that a particular area was once suitable for supporting life (e.g., warm and wet conditions).

MEP Missions	Science Objectives
Future Mars Exploration	• 2007 Mars Scout mission will be a fully competed science mission, led by a Principal Investigator (PI), to complement the MEP core program missions • U.S. contributions to 2007 International Mars missions will include programmatic and technical development support for the NASA-Agenzia Spaziale Italiana (ASI) telecommunications orbiter, and science and engineering instrumentation for the Centre National d'Etudes Spatiales (CNES) Orbiter and NetLanders. • 2009 Mars Smart Lander/Mobile Laboratory is a long-duration roving science laboratory that will conduct the next major step of in-situ science measurements and validate design and operations for future Mars landers and rovers. This mission will incorporate a nuclear power system to greatly extend the duration of surface operations, thereby significantly increasing scientific return. • Mars Technology will lay the groundwork and provide new capabilities for Mars missions beyond 2005. The technology investment in this area will include precision atmospheric entry and landing techniques, hazard avoidance systems, new in-situ sensors, optical navigation, surface power, and other ascent and mobility systems. • Construction of a Deep Space Network (DSN) 34-meter Beam-Wave-Guide (BWG) Antenna in Spain will meet DSN mission loading requirements, largely driven by MEP in FY03/04. • Construction of a Flight Projects Facility at JPL. (Refer to CofF / Mission Support section)

2003 Mars Exploration Rovers (MER)

Milestones	FY03 Date	FY02 Date	Change	Comment
Mission Selection	4Q/FY00	4Q/FY00		Completed on schedule
Mission PDR	1Q/FY01	1Q/FY01		Completed on schedule
Mission CDR	4Q/FY01	4Q/FY01		Completed on schedule
Start S/C level I&T	2Q/FY02	2Q/FY02		
Launch - 1st Lander	5/03	5/03		
Launch - 2nd. Lander	6/03	6/03		



Lead Center: JPL	**Other Centers: GRC (airbag);** LARC (Entry, descent, and landing simulation); KSC	**Interdependencies:** Gutenberg U. /Germany
Subsystem	**Builder**	
Spacecraft:	JPL	
Instruments	**Builder**	**Pr. Investigator: Steve Squyres**
Rover 1 & 2	JPL	
Mossbauer Spectrometer	Gutenberg U/Germ.	
Alpha Proton X-ray Spectrometer (APXS)	MPI/Germany	
Microscopic Imager (MI)	JPL	
Panoramic Camera (Pancam)	JPL	
Mini Thermal Emission Spectrometer (Mini-TES)	Arizona State U.	
Launch Vehicle:	**Tracking/Communication**	**Data:**
Boeing Delta 7920H & 7920	Deep Space Network	Planetary Data System (PDS)

2003 Mars Exploration Rovers (MER) – Lifecycle cost

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	Total
	18.9	296.0	245.2	122.1	41.1	17.0				740.3
Development	18.9	263.7	199.5	81.4						563.5
Launch Support		32.3	45.7	32.5						110.5
Operations				5.9	25.7	4.4				36.0
Data Analysis				2.3	15.4	12.6				30.3
[Est. Civil Servant FTE]		4	20	19	13	13				

2005 Mars Reconnaissance Orbiter (MRO)

Milestones	FY03 Date	FY02 Date	Change	Comment
S/C Selection	10/01			
Instruments selection	11/01			
PDR	4Q/02			
CDR	3Q/03			
Start I&T	3Q/05			
Launch	4Q/05			

Lead Center: JPL

Other Centers:

Interdependencies: Agenzia Spaziale Italiana (ASI)

Subsystem	Builder	
Spacecraft:	Lockheed Martin	

Instruments	Builder	Pr. Investigator
Mars Climate Sounder	JPL	D. McCleese
Mars Color Imager	Malin Space Science Systems	M. Malin
High-Resolution Imager (HIRISE)	Ball Aerospace & Technologies	Alfred S. McEwen (U. Arizona, Tucson); Science investigator
Imaging Spectrometer (CRISM)	JHU Applied Physics Lab	Scott L. Murchie; Science Investigator
Context Imager (Facility Instrument)	Malin Space Science Systems	
Shallow Radar (SHARAD) (Facility Instrument)	Italian Space Agency	

Launch Vehicle:	Tracking/Communications:	Data:
TBD -decision to be made in 5/02	Deep Space Network	Planetary Data System (PDS)

2005 Mars Reconnaissance Orbiter (MRO) – lifecycle cost

	Prior	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	BTC	Total
		12.0	57.9	143.5	173.4	103.1	32.0	36.7	66.2	624.8
Pre-Development		12.0	48.0							60.0
Development			9.9	122.5	137.3	64.7				334.4
Launch Support				21.0	36.1	33.1				90.2
Operations						3.9	21.2	19.8	46.4	91.3
Data Analysis						1.4	10.8	16.9	19.8	48.9

LINKAGES TO STRATEGIC AND PERFORMANCE PLANS

Strategic Plan Goal Supported: Chart the evolution of the universe from origins to destiny, and understanding its galaxies, stars, planets and life; and use robotic science missions as forerunners to human exploration beyond low-Earth orbit.

Strategic Plan Objectives Supported: Probe the origin and evolution of life on Earth and determine if life exists elsewhere in our Solar System; and investigate the composition, evolution, and resources of Mars, the Moon, and small bodies.

Performance Plan Metrics Supported: Annual Performance Goal (APG) #3S9, "Earn external review rating of "green," on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives."
Current and future operating missions support APG #3S6: "Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Chart the distribution of life-sustaining environments within our Solar System, and search for evidence of past and present life.
- Identify plausible signatures of life on other worlds.

PROGRAM PLANS FOR FY 2002

- 2001 Mars Odyssey took its first thermal infrared temperature image of Mars on 10/31/01; the image was an indication that the imaging system is working properly. The main science-mapping mission is expected to begin in early February 2002, and will continue throughout FY 2002.
- 2003 Mars Exploration Rover: 1st and 2nd flight systems will start Assembly, Test, and Launch Operations and environmental testing in Feb. 2002.
  - Mars Express: the US provided instruments (Radar Sounder (MARSIS) Antenna and Transmitter and RF subsystems) will be completed and delivered to ESA by the end of 2nd qtr. FY 2002.
  - 2005 Mars Reconnaissance Orbiter (MRO), NASA selected Lockheed Martin Astronautics as the spacecraft provider in October 2001, and selected all the instruments and science investigations in November 2001. A preliminary Design Review (PDR) and a Non-Advocate Review (NAR) is scheduled in the 4th qtr. of FY 2002, which will initiate a start of Phase C/D for the project also during the 4th qtr. FY 2002.
- JPL Flight Project Management Facility: refer to Mission Support – Construction of Facilities section.
- Future Mars
  1. An Announcement of Opportunity for the 2007 Mars Scout will be released in the 3rd QTR of FY 2002, allowing the mission to enter into formulation phase.
  2. U.S. contributions to both 2007 International Mars missions (CNES Orbiter and ASI Telecom) will enter into formulation phase.
  3. Mars Technology - NASA will continue to actively develop new instrument technology that could unlock the mysteries of the Martian climate and geological history through FY 2002. NASA will also continue to develop Mars-focused technologies (i.e. precision landing/aerocapture/hazard avoidance, new in-situ sensor, power and fuel production) that would enable a launch of a Smart Lander/Mobile Laboratory mission in 2009.

4. The construction and outfitting for the Deep Space Network (DSN) 34-meter Beam-Wave-Guide (BWG) Antenna in Spain to meet DSN mission loading requirements in FY 2003/04 will be ongoing throughout FY 2002.

PROGRAM PLANS FOR FY 2003

- 2001 Mars Odyssey will continue its primary science mapping throughout FY 2003.
- 2003 Mars Exploration Rovers (MER) will complete the final assembly, integration and test by the end of the 1st QTR of FY 2003. MERs will be shipped to the Kennedy Space Center (KSC) for final assembly in preparation for launches in May and June 2003. The rovers are scheduled to land on the surface of Mars in January 2004.
- Mars Express is scheduled for launch in June 2003, followed by Mars Orbit Insertion (MOI) in December 2003.
- 2005 Mars Reconnaissance Orbiter (MRO) will proceed with the full-scale implementation phase in FY 2003. A mission Critical Design Review (CDR) is expected in the 4th QTR of FY 2003.
- JPL Flight Project Management Facility: refer to Mission Support – Construction of Facilities section.
- Future Mars

1. A Step 1 selection (concept study) for the competitively selected 2007 Mars Scout mission will occur in the 1st QTR of FY 2003, followed by a Step 2 selection (flight development) in 4th QTR of FY 2003.
2. 2007 CNES Orbiter will be entering into a preliminary design of a cooperative science and technology validation by CNES and NASA, delivering NetLander science stations and other experiments.
3. 2007 ASI Telecom Orbiter (G. Marconi) will start Phase A, and will initiate and complete trade studies for different spacecraft designs and orbits in FY2003. At the end of FY 2003, 2007 ASI Telecom Orbiter will complete a Systems Requirements Review (SRR).
4. For fiscal year 2003 the Mars technology program will attend to focused technology critical to the success of the 2009 Smart Lander Mission (focused), and multimission technologies. Focused technologies include: entry, descent, and landing; surface power; and in-situ sample preparation, handling and analysis. The base or multi-mission technologies include: science instruments and systems; regional mobility and subsurface access; telecom and navigation; transportation and orbit insertion; advanced entry, descent, and landing; and information systems integration.
5. The construction for the Deep Space Network (DSN) 34 meter Beam Wave Guide (BWG) Antenna in Spain will be completed by the 3rd QTR of FY03. Outfitting, electronics installations, testing and integration will continue throughout FY03. This antenna will be fully operational by 1st QTR of FY04.

BASIS OF FY 2003 FUNDING REQUIREMENT

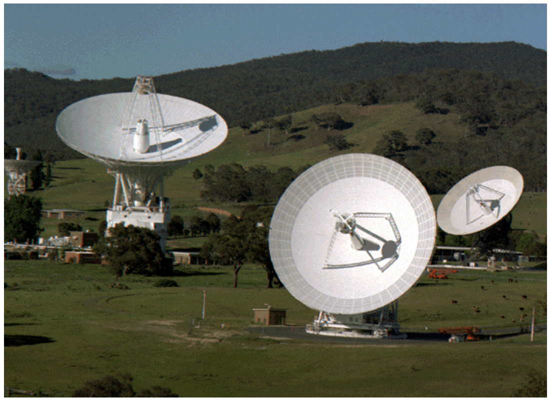
Space Science Mission Operations

Web Address: http://spacescience.nasa.gov/missions/index.htm

	FY 2001	FY 2002	FY 2003
Astronomy and Physics Operations	12.0	14.9	20.4
Sun-Earth Connections Operations	6.9	37.0	43.5
Mars Operations	18.0	24.8	26.0
Solar System Operations	85.9	98.1	295.3
Space Science Mission Operations *	**122.8**	**174.8**	**385.2**

* Includes transfer of the Deep Space Network and Mission Services from the Office of Space Flight in FY 2002/2003

MISSION OPERATIONS PROGRAM GOALS



- Maximize the scientific return from NASA's investment in spacecraft and other data collection sources by efficiently operating the data-collecting hardware that produces scientific discoveries, and maintaining the operational effectiveness of that hardware.
  - Funding supports spacecraft operations during the performance of the core missions plus extended operations of selected spacecraft.
- Work to dramatically reduce costs while preserving, to the greatest extent possible, science output.
  - Accept prudent risk, explore new conceptual approaches, streamline management and make other changes to enhance efficiency and effectiveness.
  - Utilize the savings, and seek additional cost reductions, in order to sustain operations of ongoing missions as long as is merited by the science return.

The science community both inside and outside of NASA regularly reviews the mission operations program to ensure that only the missions with the highest science return are funded.

DESCRIPTION / JUSTIFICATION

As of the end of December 2001, there are 25 operational Space Science missions (26 spacecraft), in addition to participation in seven foreign missions (ten spacecraft).

At the end of FY 2003, we expect to have as many as 28 operational Space Science missions (30 spacecraft), in addition to participation in eight foreign missions (eleven spacecraft).

While the cost of operating our missions has continued to decline, the budget for Space Science Mission Operations grows significantly from FY 2002 to FY 2003. This is due to the transfer of responsibilities from the Office of Space Flight (Space Operations) for the Deep Space Network and for Mission Services, which are described below. See page MY-2 for a normalized comparison of NASA's FY 2001, FY 2002, and FY 2003 budgets.

Beginning in FY 2003, the budget for the Deep Space Network (DSN) is included in Space Science, consistent with "full cost" budgeting and management. The transfer of management responsibility for the DSN to the Office of Space Science has already begun. JPL is working with its industry contract partners to transform the DSN and associated mission operations system architecture into a service provision system known as the Deep Space Mission System (DSMS). The DSMS will provide a customer-oriented, turnkey service that seamlessly integrates the facilities of the DSN and the Advanced Multi-Mission Operations System (AMMOS). This system will enable more efficient provision of currently available services as well as the creation of entirely new services.

The overall purpose of the DSMS program is to enable Space Science missions by providing:

- Cost-effective and reliable telecommunications services
- Cost-effective and reliable mission-operations tools, services and engineering support
- Extensions of telecommunications and mission-operations capabilities
- New technologies for telecommunications and mission operations

The DSN includes the Goldstone Deep Space Communications Complex (GDSCC) in California, the Madrid Deep Space Communications Complex (DSCC) in Spain, and the Canberra Deep Space Communications Complex (CDSCC) in Australia. The DSN plans to provide approximately 84,000 hours of tracking support to over 50 missions during FY 2002 and FY 2003. These include NASA, NASA cooperative and reimbursable spacecraft launches. Special tracking coverage is provided in support of spacecraft emergencies and anomalies. The number of missions serviced by the DSN facilities and the requirements of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems will be phased out or converted for alternate uses. More information about the Deep Space Network is available at http://deepspace.jpl.nasa.gov/dsn/

The Planetary Flight Support (PFS) program provides ground system hardware, software, and mission support for all deep-space missions. Planetary Flight Support has recently focused on the design and development of multi-mission ground operation systems for deep space and high-Earth-orbiting spacecraft, including generic multi-mission ground system upgrades such as the Advanced Multi-Mission Operations System (AMMOS). This new capability is designed to significantly improve our ability to monitor spacecraft systems, resulting in reduced workforce levels and increased operations efficiencies for Cassini and future planetary missions. New missions in the Discovery, Mars Surveyor, and New Frontiers programs will work closely with the Planetary Flight Support Office to design ground systems developed at minimum cost, in reduced time, with greater capabilities, and able to operate at reduced overall mission operations costs.

In addition to the transfer of the DSN, starting in FY 2002 the Space Science budget includes funding for Mission Services for Space Science missions, previously funded in Space Operations.

CURRENT / PROJECTED MISSIONS IN OPERATION:

The following is a comprehensive list of all Space Science spacecraft that are, or are expected to be, operational at any time between January 2002 and September 2003. Those missions whose end is specified to be "Beyond 2003" will be subjected to future review by the science community. This is to ensure that only the missions with the highest science return are funded.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Advanced Composition Explorer (ACE)	**8/25/97**	**Beyond 2003**	The spacecraft is the primary provider of real-time space weather measurements of the solar wind; also the spacecraft provides data on the composition of the solar wind and energetic particle events from the Sun.
Cassini	**10/15/97**	**~2008**	Conduct detailed exploration of the Saturnian system including: 1) the study of Saturn's atmosphere, rings and magnetosphere; 2) remote and in-situ study of Saturn's largest moon, Titan; 3) the study of Saturn's other icy moons; and 4) a Jupiter fly-by to expand our knowledge of the Jovian System. During the trip from Jupiter to Saturn, Cassini will conduct unique radio-science measurements designed to detect ripples of gravitational field produced by catastrophic events in the galaxy. Cassini will arrive at Saturn in 2004.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Chandra X-ray Observatory (CXO)	**7/23/99**	**~2009**	Obtain high-resolution x-ray images and spectra in the 0.1-to-10-KeV wavelength range; investigate the existence of stellar black holes; study the contribution of hot gas to the mass of the universe; investigate the existence of dark matter in galaxies; study clusters and superclusters of galaxies; investigate the age and ultimate fate of the universe; study mechanisms by which particles are accelerated to high energies; confirm the validity of basic physical theory in neutron stars; investigate details of stellar evolution and supernovae.
Cluster	**8/9/00**	**Beyond 2003**	Cluster is a European Space Agency program with major NASA involvement. The four Cluster spacecraft carry out three-dimensional measurements in the Earth's magnetosphere.
Comet Nucleus Tour (CONTOUR)	**July 2002**	**Beyond 2003**	Dramatically improve knowledge of key characteristics of comet nuclei, and assess their diversity, by making close approaches to at least two comets.
Cosmic Hot Interstellar Plasma Spectrometer (CHIPS)	**August 2002**	**2003**	Use an extreme ultraviolet spectrograph to study the "Local Bubble," a tenuous cloud of hot gas surrounding our Solar System that extends about 300 light-years from the Sun.
Fast Auroral SnapshoT (FAST)	**8/21/96**	**2003**	Explore the regions of the lower magnetosphere that generate the fast currents of charged particles that create the auroras.
Far Ultraviolet Spectroscopic Explorer (FUSE)	**6/24/99**	**Beyond 2003**	Measure abundances of deuterium produced by the Big Bang, the Milky Way, and distant galaxies; determine the origin and temperature of galactic gaseous clouds and observe interaction between the solar wind and planetary atmospheres.
Galaxy Evolution Explorer (GALEX)	**May 2002**	**Beyond 2003**	Use an ultraviolet telescope to explore the origin and evolution of galaxies and the origins of stars and heavy elements. Detect millions of galaxies out to a distance of billions of light years and conduct an all-sky ultraviolet survey.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Galileo	**10/18/89**	**2003**	Execute a series of close flybys of Jupiter and its moons, studying surface properties, gravity fields and magnetic fields, and characterizing the magnetospheric environment of Jupiter and the circulation of its Great Red Spot.
Genesis	**8/8/01**	**2004**	Collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis.
Geotail	**7/24/92**	**Beyond 2003**	Geotail is a Japanese program with major NASA involvement. The primary objective is to study the dynamics of the Earth's magnetotail over a wide range of distance.
Gravity Probe B	**October 2002**	**Beyond 2003**	Use extremely precise gyroscopes to test Einstein's theory of General Relativity.
High Energy Solar Spectroscopic Imager (HESSI)	**January 2002**	**Beyond 2003**	Study the physics of particle acceleration and energy release in solar flares.
Highly Advanced Laboratory for Communications and Astronomy (HALCA)	**2/12/97**	**2002**	HALCA is a Japanese program with major NASA involvement. HALCA allows imaging of astronomical radio sources with significantly improved resolution over ground-only observations.
High Energy Transient Experiment (HETE 2)	**10/9/00**	**Beyond 2003**	Carry out a multiwavelength study of gamma ray bursts (GRBs) with UV, X-ray, and gamma ray instruments. A unique feature of the mission is its capability to localize bursts with several arcsecond accuracy in near real-time aboard the spacecraft.
Hubble Space Telescope (HST)	**4/24/90**	**2010**	HST is an operational program that continues to generate major scientific discoveries. HST's instruments provide scientific data in the ultraviolet, visible, and near infrared regions of the electromagnetic spectrum.
Imager for Magnetopause-to-Aurora Global Exploration (IMAGE)	**2/15/00**	**Beyond 2003**	Study the global response of the Earth's magnetosphere to changes in the solar wind.
International Gamma-Ray Astrophysics Laboratory (INTEGRAL)	**October 2002**	**Beyond 2003**	INTEGRAL is a European Space Agency program with major NASA involvement, dedicated to fine spectroscopy and fine imaging of celestial gamma ray sources, with concurrent source monitoring in the X-ray and optical energy ranges.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Microwave Anisotropy Probe (MAP)	**6/30/01**	**Beyond 2003**	Probe conditions in the early universe by measuring the properties of the cosmic microwave background radiation over the full sky.
Mars Global Surveyor, (MGS)	**11/7/96**	**Beyond 2003**	Global mapping of the Martian atmosphere, surface, magnetic field. Also provide relay capability for the 2003 Mars Exploration Rovers.
2001 Mars Odyssey	**4/7/01**	**Beyond 2003**	Determine the elemental and chemical composition of the Martian surface.
2003 Mars Exploration Rovers (MER)	**May / July 2003**	**Beyond 2003**	Learn about ancient water and climate on Mars; read the geological record at its landing site and learn what the conditions were like when the rocks and soils were formed.
Mars Express	**June 2003**	**Beyond 2003**	Mars Express is a European Space Agency / Italian program with major NASA involvement, which will explore the atmosphere and surface of Mars from polar orbit.
Nozomi	**7/3/98**	**Beyond 2003**	Nozomi is a Japanese program with major NASA involvement, and will study the structure and dynamics of the atmosphere and ionosphere of Mars, including any interactions with the solar wind.
Polar	**2/24/96**	**Beyond 2003**	Measure the properties of the Earth's magnetosphere in the equatorial regions
Rosetta	**January 2003**	**Beyond 2003**	Rosetta is a European Space Agency program with major NASA involvement, which will rendezvous with a comet.
Rossi X-ray Timing Explorer (RXTE)	**12/30/95**	**Beyond 2003**	Study time variability in the emission of X-ray sources. This time behavior is a source of important information about processes and structures in white-dwarf stars, X-ray binaries, neutron stars, pulsars and black holes.
Student Nitric Oxide Explorer (SNOE)	**2/26/98**	**Beyond 2003**	Investigate the effects of energy from the sun and magnetosphere on the density of nitric oxide in the Earth's upper atmosphere.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Stardust	**2/7/99**	**2006**	Rendezvous with Comet Wild-2, in January 2004, and return samples of comet dust to Earth.
Space InfraRed Telescope Facility (SIRTF)	**No earlier than December 2002**	**Beyond 2003**	Explore: - The cold Universe by looking at heat radiation from objects which are too cool to radiate at optical and ultraviolet wavelengths; - The hidden Universe by penetrating into dusty regions which are too opaque for exploration in the other spectral bands; - The distant Universe by virtue of the cosmic expansion, which shifts the ultraviolet and visible radiation from distant sources into the infrared spectral region.
Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX)	**7/3/92**	**2003**	Study a wide range of solar, heliospheric, and magnetospheric scientific questions using observations of energetic particles observed from a nearly polar, low Earth orbit.
Solar and Heliospheric Observatory (SOHO)	**12/2/95**	**Beyond 2003**	SOHO is an ESA/NASA program to observe the Sun without interruption, to learn more about the solar interior, the heating of the solar corona, and the acceleration of the solar wind and solar energetic particles.
Submillimeter Wave Astronomy Satellite (SWAS)	**12/5/98**	**2002**	Study the chemical composition, energy balance and structure of interstellar clouds and the processes that lead to the formation of stars and planets.
Swift Gamma Ray Burst Explorer	**September 2003**	**Beyond 2003**	Study the position, brightness, and physical properties of gamma ray bursts.
Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)	**12/7/01**	**Beyond 2003**	Determine the temperature, density, and wind structure in the mesosphere/lower thermosphere/ionosphere region, including seasonal and latitudinal variations; determine the relative importance of various sources and sinks of energy for the thermal structure of the MLTI.
Transition Region and Coronal Explorer (TRACE)	**4/2/98**	**Beyond 2003**	Make definitive analyses of the heating and dynamics of all regions of the solar atmosphere simultaneously; coordinate TRACE observations with SOHO data; and provide new insights on coronal heating and other solar phenomena.

MISSION	LAUNCH DATE	MISSION END	Mission Objectives
Ulysses	**10/6/90**	**Beyond 2003**	Explore interplanetary solar material at high solar latitudes.
Voyager	**8/20/77, 9/5/77**	**Beyond 2003**	The two Voyager spacecraft are exploring the properties and dynamics of the outer heliosphere beyond Pluto.
Wind	**11/1/94**	**Beyond 2003**	Provide complete plasma, energetic particle, and magnetic field input for magnetospheric and ionospheric studies and determine the magnetospheric output to interplanetary space in the up-stream region. Investigate basic plasma processes occurring in the near-Earth solar wind.
X-Ray Multi-Mirror (XMM)	**12/10/99**	**Beyond 2003**	XMM is an X-ray astrophysics observatory developed by the European Space Agency, with U.S. participation. XMM enables sensitive X-ray spectroscopic observations of a wide variety of cosmic sources.
Yohkoh	**8/30/91**	**2003**	Find explanations for solar X-ray and gamma-ray emissions

BASIS OF FY 2003 FUNDING REQUIREMENT

TECHNOLOGY PROGRAM

	FY 2001	FY 2002	FY 2003
Focused Programs	294.9	369.0	636.1
Astronomical Search for Origins	111.1	195.5	278.8
Solar System Exploration	112.4	102.9	218.0
Sun-Earth Connections	46.3	56.9	117.8
Structure & Evolution of the Universe	25.1	13.7	21.5
New Millennium Program	21.6	60.2	62.8
Technology Planning	36.6	11.0	5.0
Total	**353.2**	**440.2**	**703.9**

TECHNOLOGY CROSSWALK from FY 2002 to FY 2003

Technology Program (FY 2002 Budget Structure)	Technology Program (FY 2003 Budget Structure)	Comments
Focused Programs	Focused Programs	No change
Astronomical Search for Origins	Astronomical Search for Origins	No change
Solar System Exploration	Solar System Exploration	No change
Sun-Earth Connections	Sun-Earth Connections	No change
Structure and Evolution of the Universe	Structure and Evolution of the Universe	No change
New Millennium Program	New Millennium Program	No change
Core Program	Technology Planning	Name/content change
Explorer Planning	Explorer Planning	Deleted at end of FY 2001
High Performance Computing	High Performance Computing	Deleted at end of FY 2001
Gossamer Technology	Gossamer Technology	Deleted at end of FY 2002
Space Solar Power	Space Solar Power	No funding budgeted after FY 2002
Next Decade Planning	Next Decade Planning	No change
Planetary Fight Support		Moved to Mission Operations
Information Systems		Moved to Data Analysis

DESCRIPTION / JUSTIFICATION

TECHNOLOGY PROGRAM GOAL

Develop new technologies to enable innovative and less expensive research and flight missions.

TECHNOLOGY PROGRAM OBJECTIVES

(1) Acquire new technical approaches and capabilities
(2) Validate new technologies in space
(3) Apply and transfer technology

TECHNOLOGY PROGRAM CONTENT

FOCUSED PROGRAMS

Focused Programs are dedicated to high-priority technologies needed for specific science missions. Space Science programs use an aggressive technology development approach that requires all major technological hurdles to be cleared prior to a science mission's development phase. Technology activities can encompass developments from basic research all the way to infusion into science missions. Focused Programs also includes mission studies -- the first phase of the flight program development process. Scientists work collaboratively with technologists and mission designers to develop the most effective alignment of technology development programs with future missions. This collaboration enables intelligent technology investment decisions through detailed analysis of the trade-offs between design considerations and cost. In order to ensure that the decisions resulting from mission studies are realistic and can be implemented, the studies employ new techniques for integrated design and rapid prototyping.

The FY 2003 budget includes four categories of activities under focused programs, corresponding to the four scientific themes of the Space Science Enterprise:

- Astronomical Search for Origins (http://origins.jpl.nasa.gov/)
- Solar System Exploration (formerly known as Advanced Deep Space Systems Development) (http://solarsystem.nasa.gov/)
- Sun-Earth Connections (http://sec.gsfc.nasa.gov/)
- Structure and Evolution of the Universe (http://universe.gsfc.nasa.gov/)

The major missions and technologies under development within these Themes are described on the following pages.

Keck Interferometer **http://huey.jpl.nasa.gov/keck/**
Astronomical Search for Origins Focused Technology project

Objectives:
- Detect and study planetary systems around other stars
  - Detect dust clouds around other stars
  - Detect the signature of planets as small as Uranus orbiting stars as distant as about 75 light-years away
  - Detect and characterize the atmospheres of hot, Jupiter mass planets
  - Make images of proto-stellar disks and stellar debris disks

Funding:

FY 2001	FY 2002	FY 2003
10.5	6.2	9.3

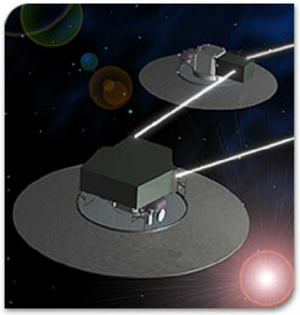
Critical New Technologies Demonstrated:
- Routine operation of a large-aperture optical interferometer on the ground

Key Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Fringe Detection	FY 01	February 2001	First combination of light from separate sources
Combine 2 telescopes	FY 01	May 2001	First combination of light from 2 main telescopes
Install first outrigger	TBD	4Q/FY 2003	Assumes permits received by May 2002

<u>StarLight</u> ***http://starlight.jpl.nasa.gov***

Astronomical Search for Origins Focused Technology mission

StarLight concept



Objectives:

- Demonstrate precision formation flying of two spacecraft
- Demonstrate separated spacecraft optical interferometry
    - Technologies required for Terrestrial Planet Finder and/or other future space observatories

Funding:

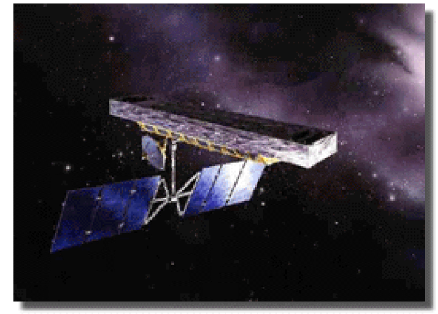
FY 2001	FY 2002	FY 2003
14.5	28.7	67.3

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
System Architecture Review	FY 01	2Q/FY02	
Preliminary Design Review	FY 02	2Q/FY03	
Implementation Start	TBD	3Q/FY03	
Critical Design Review	FY 03	FY 04	Delays in technology readiness

Space Interferometry Mission (SIM) ***http://sim.jpl.nasa.gov***

Astronomical Search for Origins Focused Technology mission

SIM concept



Objectives:

- Search 200 nearby stars for planets that are as small as three times the mass of the Earth
- Survey ~2000 stars to find planetary systems like our own, to place our solar system in context
- Study the birth of planetary systems around young stars
- Demonstrate the high-precision interferometry tools that will be needed by future space telescopes, including (potentially) Terrestrial Planet Finder

Funding:

FY 2001	FY 2002	FY 2003
29.7	34.9	39.5

Critical New Technologies Required:

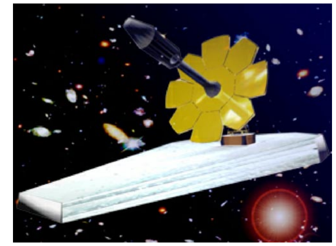
- Precision Metrology
- Vibration Isolation And Structural Quieting Systems
- Optical Delay Lines

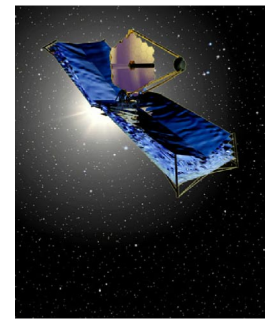
Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Metrology Testbed Demonstration	FY 02	4Q/FY02	
Systems Requirements Review	TBD	FY 04	Schedule was under review last year
Non-Advocate Review	TBD	FY 05	Schedule was under review last year

Next Generation Space Telescope (NGST) ***http://ngst.gsfc.nasa.gov***

Astronomical Search for Origins Focused Technology mission

NGST concepts





Objectives:

- investigate the early Universe by observing the first stars and galaxies
- understand the formation and subsequent evolution of galaxies
- uncover the "fossil record" of star formation for our Galaxy and dozens of neighboring galaxies
- use infrared light to see deeper inside star-forming dust clouds and measure their structures, enabling further understanding of star and planet formation
- Demonstrate the large aperture development, deployment, and management techniques that will be needed by future space telescopes, including (potentially) Terrestrial Planet Finder

Funding:

FY 2001	FY 2002	FY 2003
45.1	92.1	126.2

Critical New Technologies Required:

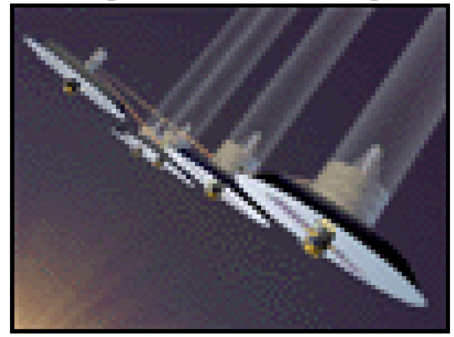
- Cryogenic lightweight deployables
- Active lightweight optics
- Low-noise, near-infrared and mid-infrared detectors
- Image-based wavefront sensing algorithms and techniques

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Spacecraft contractor selection	n/a	3Q/FY02	
System Definition Review	n/a	1Q/FY03	
Implementation Start	FY 04	FY 04	

Terrestrial Planet Finder (TPF) ***http://tpf.jpl.nasa.gov***

Astronomical Search for Origins Focused Technology mission

One possible TPF concept



Objectives:

- Directly detect Earth-like planets around other stars
- Detect chemical signatures indicating whether a planet could support life as we know it

Funding:

FY 2001	FY 2002	FY 2003
5.5	17.8	19.7

Critical New Technologies Required:

Depends upon selected mission architecture, but may include:

- Precision formation flying
- Separated spacecraft optical interferometry
- Passive cooling of telescope and detectors
- Active optics
- High contrast imaging

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Test nulling breadboard	FY 01	February 2001	
Architecture Plan	FY 02	2Q / FY 02	
Implementation Start	FY 08	TBD	Dependent on technology progress

New Horizons Pluto-Kuiper Belt Mission **http://pluto.jhuapl.edu**
Solar System Exploration Focused Technology mission

Objectives:

- Characterize the global geology and morphology of Pluto and Charon
- Map surface composition of Pluto and Charon
- Characterize the neutral atmosphere of Pluto and its escape rate

Funding:

FY 2001	FY 2002	FY 2003
	30.0	

Critical New Technologies Required:

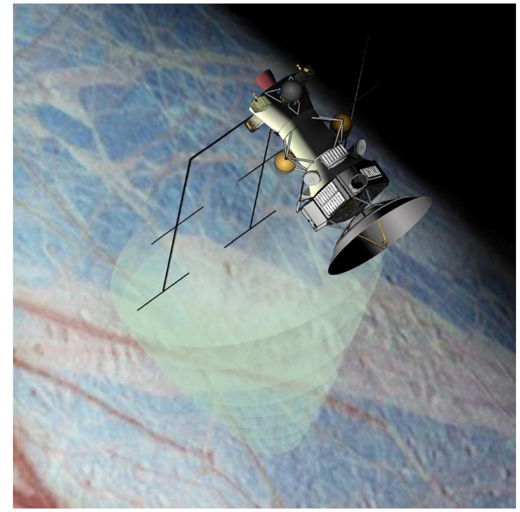
- None

Status:

- Congressional direction in the Fiscal 2002 appropriation provided funding and program direction to initiate PKB spacecraft and science instrument development and launch vehicle procurement
- No funding for FY 2003 or subsequent years is included in this budget request; the application of all available funding from the Solar System Exploration Focused Technology Program in FY 2003 to this mission would be insufficient to meet mission requirements
- "New Horizons: Shedding Light on Frontier Worlds" selected on November 29, 2001 to proceed with Phase B (preliminary design studies)
- Scientific value is highly dependent on an ambitious schedule (NEPA and launch vehicle qualification) for a 2006 launch that achieves flyby of Pluto NLT 2020

Europa Orbiter/X-2000 ***http://www.jpl.nasa.gov/europaorbiter***

Solar System Exploration Focused Technology mission



Due to high cost growth and schedule delays, the Europa Orbiter mission is cancelled. Because other Space Science missions rely on X-2000 deliveries, funding to complete the X-2000 avionics package is continued. The X2000 hardware is the next generation of high performance, radiation hardened, space flight avionics. The technologies are targeted for deep space missions, but are applicable to other NASA, commercial or DOD missions.

Objective:

- Develop high performance, low power, low mass core electronics, which can be used in a plug and play mode
- Provide a steady progression of advanced, reusable, common software technology within a flexible, but complete architecture framework that enables rapid spacecraft development/deployment

Salient Features:

- Radiation Hardened Avionics
- Next Generation Autonomy
- Long Life (14 years)/High Reliability Electronics
- Potential Mission Customers: Deep Impact, ST5 (Nanosat Constellation Trailblazer), Mars 05 and 07, SIM, DoD

Status:

- Focus in FY 2002 is directed towards X-2000 avionics development
- X-2000 Avionics effort re-planned for more realistic schedules accounting
- Adjusted schedules based on experience with other recently completed X2000 tasks
- Accounts for limited personnel availability in key skills
- Greater rigor of incremental technical reviews
- Distributed schedule margins through each development, rather than at end
- Greater conservatism in planning developments requiring unproven capabilities

Funding:

FY 2001	FY 2002	FY 2003
87.3	30.8	30.0

Nuclear Power Program
Solar System Exploration Focused Technology

The Nuclear Power Program is one of three new nuclear technology elements included in this budget. The other two elements are the Nuclear Electric Propulsion Program (discussed on the following page), and the incorporation of a nuclear power system on the Mars 2009 Smart Lander/Mobile Laboratory mission (discussed under the Mars Exploration Program).

Objective:

- Dramatically increase the potential scientific return of missions by:
  - Increasing the operational lifetime and productivity of spacecraft and instruments
  - Enabling multiple landers on a single mission
  - Providing energy for high-power planetary survey instruments for remote sensing and deep atmosphere probes
  - Allowing high bandwidth communications
- Planetary exploration missions are otherwise reliant on solar energy power generation and battery power storage systems
- Nuclear power offers an increase in overall science productivity by one to two orders of magnitude over solar power

Funding:

FY 2001	FY 2002	FY 2003
		79.0

Salient Features:

- Management oversight responsibility for the Nuclear Power Program will be assigned to the Glenn Research Center
- Funding supports parallel path competition during first two years between two alternate technologies: radioisotope thermoelectric generators (RTGs) and Stirling power generators
- Purchase of nuclear fuel will be handled through the Department of Energy
- Program also provides for technology developments for advanced instruments and for an advanced radioisotope power system

Nuclear Electric Propulsion Program
Solar System Exploration Focused Technology

The Nuclear Electric Propulsion Program is one of three new nuclear technology elements included in this budget. The other two elements are the Nuclear Power Program (discussed on the previous page), and the incorporation of a nuclear power system on the Mars 2009 Smart Lander/Mobile Laboratory mission (discussed under the Mars Exploration Program). A nuclear electric propulsion engine would use a nuclear power source to generate electricity and propel ionized gas out of a rocket nozzle. This is potentially a much more efficient way to accelerate spacecraft than using chemical rockets, creating much more thrust per pound of fuel.

Objectives:

- Significantly reduces the cruise time for spacecraft to reach distant targets
- Allows the use of smaller launch vehicles thereby reducing total mission costs
- Enables entire new class of planetary exploration missions with multiple targets
- Saves operation costs by reducing the amount of time a spacecraft is in its operations phase
- Reduces or eliminates launch windows required for gravity assists

Funding:

FY 2001	FY 2002	FY 2003
		46.5

Salient Features:

- Management oversight responsibility for the Nuclear Electric Propulsion Program will be assigned to the Marshall Space Flight Center, with significant participation from the Glenn Research Center
- This is a technology development program; it does not include the cost of potential flight units
- Resolution of key subsystem design issues in 2003: e.g., 9,000 sec ion engine proof-of-concept, 50 kg/kW reactor power subsystem design, Brayton preliminary design
- Technology assessments at Systems Readiness Review (2003) and Preliminary Design Review (2005) provide key decision points
- Transitions to flight demonstration programs in about 2005 only after clear milestones have been achieved
- Operation of reactor, power conversion and thruster engineering design units (EDU) by 2005 to provide reference for flight system design

In-Space Propulsion
Solar System Exploration Focused Technology (in FY 2001 and prior years, funding for In-Space Propulsion was carried in the Aerospace Technology Enterprise)

Objectives:
- Reduce or eliminate need for gravity assists; launch any year
- Shorter trip times
- Ability to reach new science vantage points and modify orbits during observational phase
- Minimize launch vehicle requirements to reduce cost
- Increase payload delivery capability – more mass for science, greater margins
- Includes funding for Propulsion Research Laboratory Construction ($22.0M) in FY 2002, consistent with the Congressional earmark in the FY 2002 appropriation

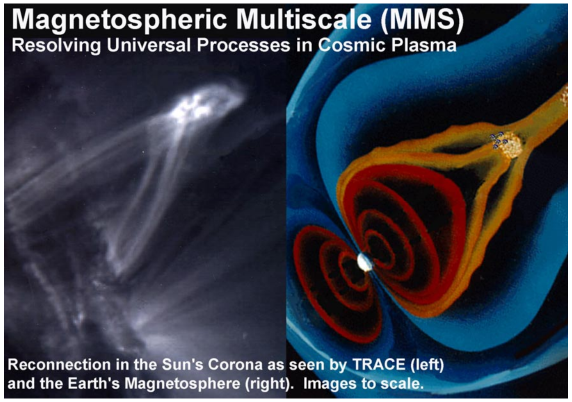
Funding:

FY 2001	FY 2002	FY 2003
	41.6	62.5

Critical New Technologies Required:
High Priority
- Next Generation Ion Engine
- Aerocapture
- Advanced funding for Nuclear Electric Propulsion (NEP) in FY 2002
- Solar Sails

Medium Priority
- High Power Electric Thrusters
- Solar Electric Propulsion Hall Thrusters
- Advanced Chemical

Magnetospheric Multiscale (MMS) **http://stp.gsfc.nasa.gov/missions/mms/mms.html**
Sun-Earth Connections (SEC) Focused Technology mission



Reconnection in the Sun's Corona as seen by TRACE (left) and the Earth's Magnetosphere (right). Images to scale.

Objectives:

- MMS will determine the small-scale basic plasma processes that transport, accelerate and energize plasmas in thin boundary and current layers -- and which control the structure and dynamics of the Earth's magnetosphere.
- MMS will for the first time measure the 3D structure and dynamics of the key magnetospheric boundary regions, from the subsolar magnetopause to the distant tail.
- MMS will pave the way for future Constellation-type missions.

Funding:

FY 2001	FY 2002	FY 2003
.5	2.3	9.0

Critical New Technologies Required:

- Make advances in spacecraft systems miniaturization and small satellite manufacturing techniques.
- Advances in instrument miniaturization, data systems, spacecraft attitude control, inter-spacecraft communication, spacecraft autonomous operation, and ground operations.

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Release Draft AO of MMS ISST	03/02	03/02	(Instrument Suite Science Team)
ISST Proposals Due	08/02	08/02	
Initiate Phase A Study	11/02	11/02	

Solar Dynamics Observatory (SDO) ***http://lws.gsfc.nasa.gov/sdo.htm***
Sun-Earth Connections (Living With a Star) Focused Technology mission

Objective:

- Observe the Sun's dynamics to further our understanding of the nature and source of the Sun's variations, from the stellar core to the turbulent solar atmosphere.

Funding:

FY 2001	FY 2002	FY 2003
1.7	8.6	26.6

Key Technologies: Large format, fast read-out CCDs and enhancing technologies at the subsystem or component level.

Key Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Release Announcement of Opportunity (AO)	FY 2002	Jan. 2002	
AO Awards	--	1st Qtr. FY 2003	
Preliminary Design Review (PDR)	--	FY 2004	
Confirmation Review (CR)	--	FY 2004	

<u>Geospace Missions</u> ***http://lws.gsfc.nasa.gov/geospace.htm***
Sun-Earth Connections (Living With a Star) Focused Technology mission

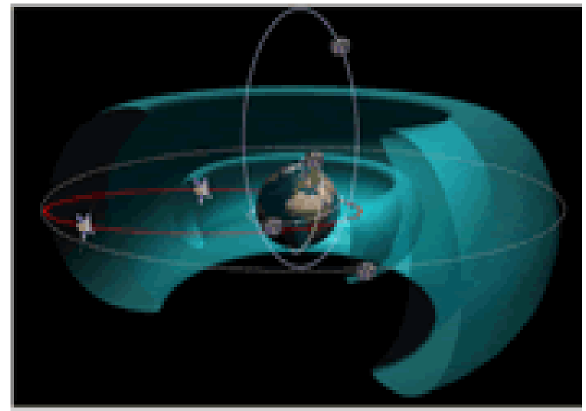
Objective:

- Increase scientific understanding of how the Earth's ionosphere and magnetosphere respond to changes due to solar variability

Funding:

FY 2001	FY 2002	FY 2003
	13.3	48.5

Key Technologies: Miniaturization of Geospace Instruments



Geospace satellites studying the Earth's ionosphere and magnetosphere

Key Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Release Instrument Announcement of Opportunity (AO)	--	4th Qtr. FY 2002	
AO Awards	--	2nd Qtr. FY 2003	

Constellation-X ***http://constellation.gsfc.nasa.gov***

Structure and Evolution of the Universe Focused Technology mission

Constellation-X concept

Constellation-X is a team of powerful X-ray telescopes that will orbit close to each other in space. These telescopes will work in unison to simultaneously observe the same distant objects, combining their data and becoming 100 times more powerful than any single X-ray telescope that has come before it.

Objectives:

- Probe the nature of black holes, ranging from those in the Milky Way galaxy that are 10-100 times as massive as the Sun, to those in the cores of distant quasars that are more than 1 million times as massive as the Sun.
- Measure chemical abundances in the universe over cosmic time, to record the history of the Universe and help build models of how the Universe may evolve in the future.
- Provide new clues to the nature of the mysterious "dark matter", which is the dominant form of mater in the Universe.

Funding:

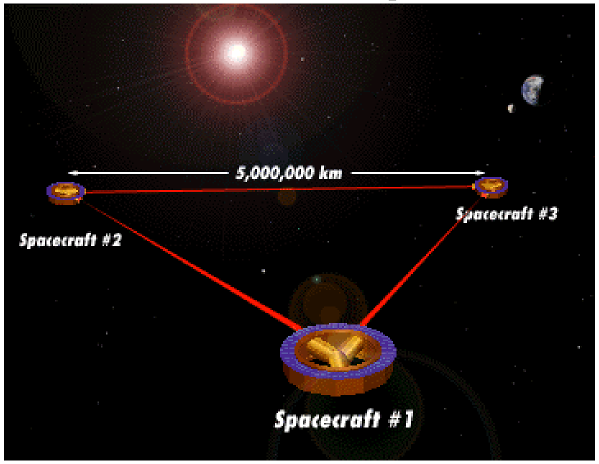
FY 2001	FY 2002	FY 2003
2.0	6.4	12.8

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Complete Formulation Authorization Document	n/a	4Q / FY 03	No milestones identified in FY 2002 Budget

Laser Interferometer Space Antenna (LISA) ***http://lisa.jpl.nasa.gov/***

Structure and Evolution of the Universe Focused Technology mission

LISA concept



The Laser Interferometer Space Antenna (LISA) consists of three spacecraft flying 5 million kilometers (km) apart in the shape of an equilateral triangle, as shown in the image at right. LISA will observe gravitational waves, which are one of the fundamental building blocks of our theoretical picture of the universe. Although there is strong indirect evidence for the existence of gravitational waves, they have not yet been directly detected.

Objectives:

- Observe gravitational waves from sources involving massive black holes
- Observe gravitational waves from thousands of double-star systems, and be able to determine the number and distribution of such systems in our Milky Way galaxy.
- Search for a possible cosmic background of gravitational waves, a remnant from the Big Bang.

Funding:

FY 2001	FY 2002	FY 2003
.2	6.2	7.3

Key Formulation Milestones:	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	COMMENT
Formulation Approval Document signed	n/a	2Q / FY 2003	Approval to begin Phase A study

Other Focused Technology Program Elements

In addition to the strategic missions listed above, the Focused Technology Program provides for activities in each theme that support future missions. These activities include the evaluation of mission concepts and early technology development. The goal of this work is to retire technology risk as early as possible during the lifecycle of a mission. In addition, this funding provides for the initial development of future missions after they have been evaluated and selected. The total budget for other Focused Technology Program elements is shown below, followed by a list of activities in each theme.

Funding:

FY 2001	FY 2002	FY 2003
97.9	50.1	51.9

Key Activities:

Astronomical Search for Origins

- Phase B planning funding for Herschel and GLAST in FY 2001 (see Development sections for complete lifecycle costs)
- Large Binocular Telescope Interferometer
- Interferometry Science Center
- Navigator Program Office
- Future Origins mission studies

Solar System Exploration

- Center for Integrated Space Microsystems
- Pluto-Kuiper Express (FY 2001 only; replaced by New Horizons mission in FY 2002 as shown above)
- Future Solar System Exploration missions

Sun-Earth Connections

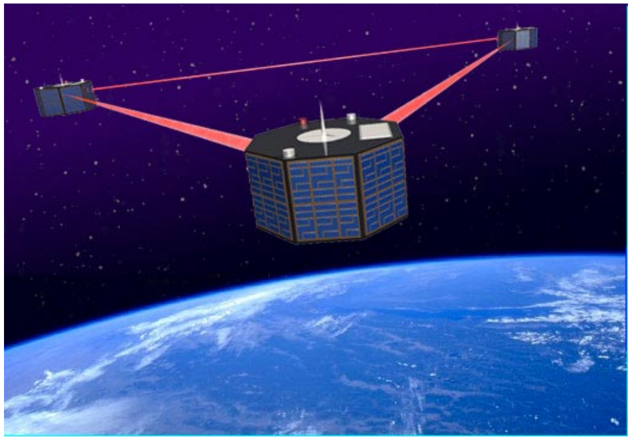
- Phase B planning funding for STEREO in FY 2001 (see Development section for complete lifecycle costs)
- Solar Probe
- Future Solar-Terrestrial Probes (e.g., Geospace Electrodynamic Connections and Magnetospheric Constellation)
- Future Living With A Star (LWS) missions (e.g., Solar Sentinel Missions) and other LWS elements:
    - Space Environment Testbeds
    - Theory and Modeling

Structure and Evolution of the Universe

- Future Structure and Evolution of the Universe missions

NEW MILLENNIUM PROGRAM

Space Technology 5 (ST5) Concept



The **New Millennium Program** provides a path to flight-validate key emerging technologies to enable more capable and more frequent science missions. Through the New Millennium Program, high-value technologies are made available for use in the Space Science program without imposing undue cost and risk on individual science missions. This program was restructured to increase its levels of openness and competitiveness, to reduce the size and cost of the missions, and to ensure focus on technology demonstration, versus science data gathering. The program includes validation of both complete systems and subsystems. NASA plans to enable two small ($40-50 million each) and one medium ($100-150 million) system validations every four years, along with two-to-three subsystem validations per year, including carrier and secondary launch. Partnerships with industry, universities, and other government agencies are pursued, where feasible, to maximize both the return on investment in technology development and rapid infusion.

Milestones	FY02 Date	FY03 Date	Change	Comment
ST-5 CDR	FY02	4/02		Complete Critical Design Review
ST-6 Project Selections	FY01	--		Completed FY01
ST-7 Project Selections	FY01	--		Completed FY01
ST-8 Project Selections	--	9/02		
ST-6 Project Approval	FY01	--		Completed FY01
ST-7 Project Approval	--	2/02		
ST-8 Project Approval	--	FY03		
ST-6 Confirmation Review	FY02	6/02		
ST-7 Confirmation Review	--	FY03		
ST-8 Confirmation Review	--	FY04		
ST-6 CDR	FY02	9/02		
ST-7 CDR	--	FY03		
ST-8 CDR	--	FY04		
New Millennium Carrier-1 (NMC-1) Confirmation Review	FY02	FY03	+1 FY	ST-6 selections do not require NMC host; NMC delayed to accommodate ST-8 schedule.

NEW MILLENNIUM PROGRAM STATUS / NOTIFICATIONS / PLANS THROUGH 2002

The Space Technology-5 (ST-5) constellation of three small satellites, also called the Nanosat Constellation Trailblazer project, was confirmed for Implementation in November 2001. Results of the ST-5 project will be used to design future missions requiring constellations of lightweight, highly miniaturized spacecraft. Critical Design Review (CDR) for ST-5 is planned for completion in FY 2002.

Three Space Technology-6 (ST-6) subsystem technologies were selected for Formulation Refinement (Phase B) in October 2001. Selected technologies include a low power avionics sensor suite featuring a miniature active pixel sensor star camera and Micro Electro Mechanical System (MEMS) gyro, which provides precision attitude determination for long duration space science missions in a very low mass, very low power package. The low mass, low power characteristics of this technology free up critical spacecraft resources that can then be used for scientific payloads. Another technology, Autonomous Rendezvous, provides a demonstration of capabilities that significantly enhance in-space rendezvous operations, which are critical for space science sample return and small body landing missions. Finally, an Autonomous Sciencecraft technology demonstration uses on-board science analysis algorithms to dramatically increase science data return. Using intelligent downlink selection and data-driven science targeting, this technology will enable radically different mission operations approaches for both earth and space science missions. Confirmation reviews for the ST-6 technology experiments are scheduled for completion in FY 2002.

A Technology Announcement for the Space Technology-7 (ST-7) mission was issued to competitively solicit technology providers to join Phase A study teams for the identified system concepts: Solar Sail, Aerocapture/Aeroentry, Disturbance Reduction System, and Spacecraft Autonomy. Study reports for each concept will be evaluated and a single concept will be down-selected for Formulation Refinement (Phase B) during FY 2002.

Space Technology-8 (ST-8) represents NMP's second subsystem technology validation opportunity. ST-8 technology providers will be competitively selected during FY 2002. Phase B activities for New Millennium Carrier-1 (NMC-1) will also be initiated in order that ST-8 technology experiments each have an equal opportunity for being hosted on a carrier spacecraft. The New Millennium Carrier Project seeks to develop low cost access-to-space approaches to accommodate subsystem-level technologies (e.g., ST-6, ST-8) for flight validation. Approaches include providing a means of accommodating the flight validations via existing host spacecraft, or utilizing a small, dedicated free-flying platform to host multiple subsystem technology experiments.

NEW MILLENNIUM PROGRAM PLANS FOR FY 2003

During FY2003, the New Millennium Program plans to confirm the selected ST-7 system concept for Implementation (Phase C), receive approval to proceed to Formulation Refinement (Phase B) for the competitively selected ST-8 subsystem technology experiments, and approve NMC-1 for Implementation (Phase C) in support of ST-8. Project selections (Phase A) for Space Technology-9 (ST-9) are also planned for FY2003.

TECHNOLOGY PLANNING

As shown in the budget crosswalk at the beginning of the technology section, the Technology Planning (formerly called Core Technology) contains only one element after the end of FY 2002. This element: Next Decade Planning, supports intra-agency planning to develop and refine a robust set of potential civil space programs that could be undertaken in the next decade. This planning effort is generating roadmaps that will aid in selecting technologies aimed at enabling these future programs.

Two additional elements of the former Core Technology Program will continue after FY 2002, but have been transferred to other program elements. Planetary Flight Support (PFS) provides services such as ground system hardware, software, and mission support for all deep space missions. It also supports the development of generic multi-mission ground system upgrades such as the Advanced Multi-mission Operations System (AMMOS). Although PFS has technology development elements, it has direct and immediate benefits to the operations program, and we are transferring it to Mission Operations.

Another element of the former Core Technology Program, Information Systems, is moving into Data Analysis, where it will be called Science Data and Computing Technology. Following a detailed review of this program element, and the elimination of one of its three components after FY 2002, it has been determined that this effort is in direct support of mission data analysis, and consequently it has been moved to the Data Analysis program.

BASIS OF FY 2003 FUNDING REQUIREMENT

RESEARCH PROGRAM

	FY 2001	FY 2002	FY 2003
Research and Analysis	242.5	255.5	272.9
Data Analysis	328.9	347.3	387.2
Suborbital	41.6	41.6	44.3
Balloon Program	15.3	14.0	14.0
Sounding Rockets	26.3	27.6	30.3
Program Construction of Facilities		2.2	5.2
Total	**613.0**	**646.6**	**709.6**

DESCRIPTION / JUSTIFICATION

Scientific research is the foundation of the Space Science Enterprise. Underpinning the space science flight programs, the Research Program develops the theoretical tools and laboratory data needed to analyze flight data, makes possible new and better instruments to fly on future missions, and analyzes the data returned so that we can answer specific questions posed and fit them into the overall picture. Without a vigorous Research Program it would not be possible to conduct a scientifically meaningful flight program. Examples of the contributions of the Research Program abound across the whole frontier of space science.

RESEARCH & ANALYSIS

GOALS

- Enhance the value of current space missions by carrying out supporting ground-based observations and laboratory experiments;
- Conduct the basic research necessary to understand observed phenomena and develop theories to explain observed phenomena and predict new phenomena, thereby yielding scientific questions to motivate subsequent missions;
- Continue the synthesis, analysis, interpretation and evaluation of data from laboratories, airborne observatories, balloons, rocket experiments and spacecraft data archives;
- Develop and promote scientific and technological expertise in the U.S. scientific community.

CONTENT

The Research and Analysis Program provides grants to non-NASA research institutions throughout the Nation, and funds scientists at NASA Field Centers.

- The Enterprise NASA Research Announcement (NRA) for Research Opportunities in Space Science (ROSS) solicits proposals for basic investigations to seek to understand natural space phenomena across the full range of space science programs.
- Approximately **1,500 grants are awarded each year** after a rigorous peer-review process.
- Participation in this program is **open to all categories of U.S. and non-U.S. organizations** including educational institutions, industry, nonprofit institutions, NASA Centers, and other Government agencies.
- Only about **one out of four proposals is accepted for funding**, making this research program among the most competitive in government.
- The Program also develops new types of detectors and other scientific instruments, many of which are tested and flown aboard sounding rockets or balloons.

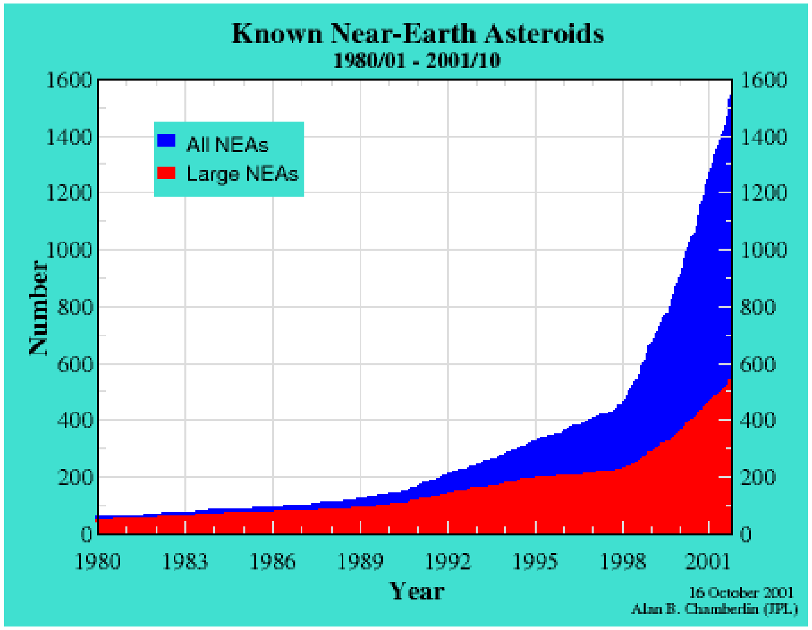
The Program also supports publication and dissemination of the results of new missions, both inspiring and enabling cutting-edge research into the fundamental questions that form the core of the mission of the Space Science Enterprise.

- Currently, with the exception of a proprietary period of up to one year for some missions, 100% of the data from current and past Space Science missions is openly available to the public via the internet; i**n the future, these proprietary periods will be phased out completely.**
- Minority and disadvantaged institutions are particularly encouraged to apply.
- Recommendations for funding are based on the independent evaluation of each proposal's science and technical merits, and its relevance to the Space Science Enterprise objectives as described in the NRA.

MILESTONES	FY 2002 BUDGET DATE	FY 2003 BUDGET DATE	CHANGE	COMMENT
Issue FY 2001 NASA Research Announcement (NRA)	2nd Qtr, FY 01	1/26/01		
Issue FY 2002 NASA Research Announcement (NRA)	2nd Qtr, FY 02	1/02		
Issue FY 2003 NASA Research Announcement (NRA)	N/A	2nd Qtr, FY 03		

MAJOR RESEARCH & ANALYSIS RESULTS IN THE PAST YEAR

Our R&A program continued to produce exciting scientific results in 2001. The Near-Earth Object (NEO) Program Office at JPL continues to focus on the goal of locating at least 90 percent of the asteroids and comets that approach the Earth and are larger than about 2/3-mile (about 1 kilometer) in diameter, by the end of the next decade. These are objects that are difficult to detect because of their relatively small size, but are large enough to cause global effects if one were to hit the Earth. Detection, tracking, and characterization of such objects are all critical. As additional telescopes and improved detectors have been added to the search, the detection rate has continued to increase. Current estimates (based on a statistical analysis of the objects located to date) are that approximately half of the NEO's have been located. More information about NEO's is available at http://neo.jpl.nasa.gov



Detailed scientific analysis of high-resolution images obtained by the BOOMERANG (Balloon Observations of Millimetric Extragalactic Radiation and Geophysics) balloon mission provided the most precise measurements to date of several of the key characteristics cosmologists use to describe the Universe. These images were the first to bring the cosmic microwave background (the radiation remaining from the "big bang" that created the Universe) into sharp focus. More information about BOOMERANG is available at http://www.physics.ucsb.edu/~boomerang/

Many discoveries in 2001 related to the rapidly growing field of extrasolar planet (planets outside our Solar System) detection. Astronomers announced the discovery of over 20 new extrasolar planets in 2001, bringing the total number of extrasolar planet detections to about eighty. The latest discoveries uncovered more evidence of what the astronomers are calling a new class of planets, with circular orbits similar to the orbits of planets in our solar system. At least two of the recently detected planets have approximately circular orbits. The majority of the extrasolar planets found to date are in elongated, or "eccentric," orbits, which are thought to be less conducive to life. More information about exoplanets is available at http://exoplanets.org/

In recognition of the interrelationship between the origin and evolution of life and the origin and evolution of planets, a new program within the framework of Astrobiology was initiated in 1997. A multi-disciplinary Astrobiology Institute was established with members from geographically distributed research institutions, linked through advanced telecommunications. In 2001, the discovery of fossilized remnants of a microbial mat provided evidence that life existed on land as early as 2.6 to 2.7 billion years ago. The findings suggest that an oxygen atmosphere and a protective ozone layer were in place around Earth by that time. Other research provided evidence that Earth's most severe mass extinction -- an event 250 million years ago that wiped out 90 percent of the life on Earth -- was triggered by a collision with a comet or asteroid. More information about Astrobiology is available at http://nai.arc.nasa.gov/

DATA ANALYSIS PROGRAM

GOALS

- Maximize the scientific return from our space missions, within available funding.
- Contribute to public education and understanding of science through media attention and our own education and outreach activities.

CONTENT

Provide funding support to scientific teams using data from our spacecraft.

- Depending on the mission, scientists supported may include Principal Investigators who have built hardware and been guaranteed participation, Guest Observers who have successfully competed for observing time, and researchers using archived data from current or past missions.

Fund a number of critical "Science Center" functions that are necessary to the operation of the spacecraft but do not involve the actual commanding of the spacecraft.

- The planning and scheduling of spacecraft observations, the distribution of data to investigators, and data archiving services are all supported under Data Analysis.

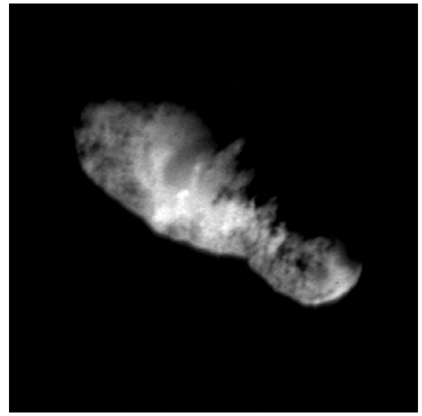
MAJOR DATA ANALYSIS RESULTS IN THE PAST YEAR

NASA's Space Science spacecraft continue to generate a stream of scientific discoveries. Many of these findings are of broad interest to the general public, as demonstrated by widespread media coverage. Recent highlights include results from the Hubble Space Telescope, the Chandra X-ray Observatory, the Near Earth Asteroid Rendezvous (NEAR), Mars Global Surveyor, Galileo, the Rossi X-Ray Timing Explorer (RXTE), and the Solar and Heliospheric Observatory (SOHO). However, many other Space Science spacecraft have been "in the news" and extremely scientifically productive as well. Listed below are just a few of the top science stories of the past year from NASA Space Science missions.

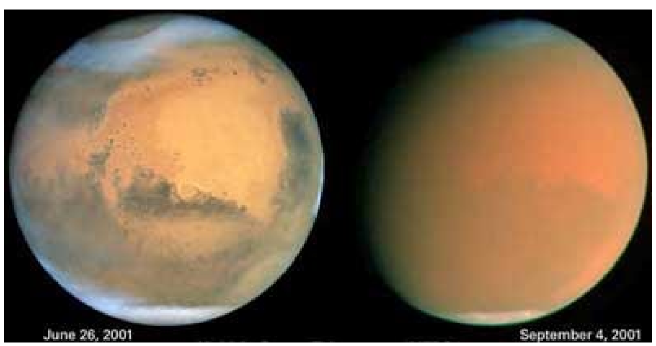
The Hubble Space Telescope discovered a supernova blast that occurred very early in the life of the Universe, bolstering the case for the existence of a mysterious form of “dark energy” pervading the Universe. The concept of dark energy, which pushes galaxies away from each other at an ever-increasing speed, was first proposed, and then discarded, by Albert Einstein early in the last century. The Hubble discovery also reinforces the startling idea that the universe only recently began speeding up. This and other HST findings are available at http://hubble.stsci.edu

The Chandra X-ray Observatory enhanced the understanding of black holes on many fronts. Chandra took the deepest X-ray images ever and found the early Universe teeming with black holes, probed the theoretical edge of a black hole known as the event horizon, and captured the first X-ray flare every seen from the supermassive black hole at the center of our own Milky Way galaxy. This and other CXO findings are available at http://chandra.harvard.edu .

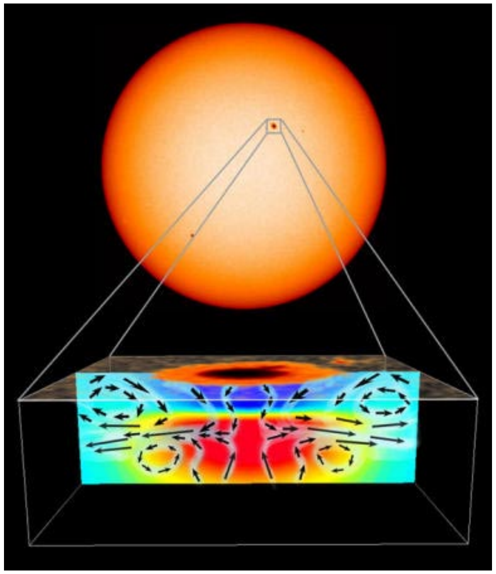
In a risky flyby, the Deep Space 1 (DS1, http://nmp.jpl.nasa.gov/ds1) spacecraft successfully navigated past comet Borrelly, giving researchers the best look ever inside the glowing core of icy dust and gas. DS1 passed just 2,200 kilometers (1,400 miles) from the rocky, icy nucleus of the 10 kilometer-long (more than 6 mile-long) comet. The NEAR (Near Earth Asteroid Rendezvous, http://near.jhuapl.edu) Shoemaker spacecraft achieved the first soft landing on an asteroid. The landing was the culmination of a year-long orbital mission at the asteroid Eros during which the mission returned enormous quantities of scientific data and images.



Many discoveries in 2001 related to the rapidly growing field of extrasolar planets (planets outside our Solar System). Observations from the Submillimeter Wave Astronomy Satellite (SWAS, http://sao-www.harvard.edu/swas/) provided the first evidence that extrasolar planetary systems contain water, a molecule that is an essential ingredient for known forms of life. Also in this field, astronomers using the Hubble Space Telescope have made the first detection and chemical analysis of the atmosphere of a planet outside our Solar System.



A pair of spacecraft, the Mars Global Surveyor and the Hubble Space Telescope, provided astronomers with a ringside seat to the biggest global dust storm seen on Mars in several decades. The Martian dust storm, larger by far than any seen on Earth, raised a cloud of dust that engulfed the entire planet for several months. The sun-warmed dust raised the atmospheric temperatures by 80 degrees F while the shaded surface chilled precipitously. Also in 2001, the Mars Odyssey 2001 spacecraft successfully achieved orbit around Mars following a six month, 286 million mile journey. The spacecraft will be placed in its final science mapping orbit in February 2002; it will characterize composition of the Martian surface at unprecedented levels of detail. More information is at http://mars.jpl.nasa.gov/



Anatomy of a sunspot - below the surface

In the field of Sun-Earth Connections, where we seek to develop a scientific understanding of the physical interactions in the Sun-Earth system, there were several important scientific accomplishments in 2001. The Solar and Heliospheric Observatory (SOHO, http://sohowww.nascom.nasa.gov/) observed the largest sunspot in ten years, with a surface area as big as the surface area of thirteen Earths. This area proved to be a prolific source of stormy solar activity, hurling clouds of electrified gas (know as Coronal Mass Ejections, or CME's) towards Earth. Other studies conducted by the SOHO spacecraft have provided the first clear picture of what lies beneath sunspots, peering inside the Sun to see swirling flows of electrified gas that create a self-reinforcing cycle which holds a sunspot together.

SUBORBITAL PROGRAM

GOALS

- Provide frequent, low-cost flight opportunities for space science researchers to fly payloads to conduct research of the Earth's ionosphere and magnetosphere, space plasma physics, astronomy, and high-energy astrophysics.

- Serve as a technology testbed for instruments that may ultimately fly on orbital spacecraft, thus reducing cost and technical risks associated with the development of future space science missions.

- Provide the primary opportunity for training graduate students and young scientists in hands-on space flight research techniques.

CONTENT

The suborbital program provides the science community with a variety of options for the acquisition of in-situ or remote sensing data, using aircraft, balloons and sounding rockets to provide access to the upper limits of the Earth's atmosphere. Activities are conducted on both a national and international cooperative basis.

Balloons **http://www.wff.nasa.gov/~code820/**

The Balloon Program is a level-of-effort flight program that:

- Provides a cost-effective way to test flight instrumentation in the space radiation environment, and to make observations at altitudes above most of the water vapor in the atmosphere.

- Provides the only means of flying some primary scientific experiments, due to their size, weight or cost.

- Iis particularly useful for infrared, gamma ray, and cosmic ray astronomy.

The Balloon Program develops new technologies to improve payload size and flight duration:

- The program has successfully developed balloons capable of lifting payloads greater than 5000 pounds.

- Balloons are now also capable of conducting a limited number of missions lasting 9 to 24 days, and successful long-duration flights are being conducted in or near both Polar Regions.

- Analytical tools have been developed to predict balloon performance and flight conditions.

- These tools are being employed to analyze new balloon materials in order to develop an ultra-long-duration balloon (ULDB) flight capability (approximately 100 days), based on super-pressure balloons.

- An integrated management team has been established to develop and test the balloon vehicle and balloon-craft support system.

The GSFC Wallops Flight Facility (WFF) manages the Balloon contract. The National Scientific Balloon Facility (NSBF), a government-owned, contractor-operated facility in Palestine, Texas, conducts flight operations.

<u>Sounding Rockets</u> **http://rscience.gsfc.nasa.gov/**

The Sounding Rockets Program performs low-altitude measurements (between balloon and spacecraft altitude) for which rockets are uniquely suited, including the measurement of the vertical variation of many atmospheric parameters.

The Sounding Rockets Program supports special areas of study, such as:

- The nature, characteristics and composition of the magnetosphere and near space;

- The effects of incoming energetic particles and solar radiation on the magnetosphere, including aurora production and energy coupling into the atmosphere;

- The nature, characteristics and spectra of radiation of the Sun, stars and other celestial objects.

The Sounding Rockets Program allows several science disciplines to flight-test instruments and experiments being developed for future space missions, and also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft.

Launch operations are conducted from facilities at WFF, Virginia; White Sands, New Mexico; and Poker Flat, Alaska, as well as occasional foreign locations. A performance-based contract, managed by the GSFC/WFF, was awarded February 1999 to allow the government to transition away from operational control.

MAJOR SUBORBITAL RESULTS IN THE PAST YEAR

In FY 2001, 11 balloons were flown for the core (short duration flights) program, of which 10 were successful flights, with one balloon failure. Two successful long duration flights were conducted from Antarctica, and two Ultra-Long Duration test flights were conducted from Australia, one of which succeeded and the other failed. During FY 2002, we expect about 18 flights, including one Long Duration flight from Alaska.

In FY 2001, 12 sounding rocket missions were flown, of which all were successful flights. The sounding rocket program plans to launch 41 missions in FY 2002, anticipating that at least half will be ready and have no complications.

PROGRAM PLANS FOR FY 2003

In FY 2003 the Balloon Program expects to launch about 18 missions, including Long-Duration flight from Antarctica. The Sounding Rocket program plans to launch 20 missions.

BASIS OF FY 2003 FUNDING REQUIREMENT

SPACE SCIENCE INSTITUTIONAL SUPPORT

	FY 2001	FY 2002	FY 2003
		(Millions of Dollars)	
Institutional Support to Space Science Enterprise	[285.6]	356.7	369.8
Research and Program Management	[258.8]	329.0	342.3
Personnel and Related Costs	[204.0]	248.1	265.4
Travel	[6.3]	7.3	7.4
Research Operations Support	[46.9]	73.6	69.5
Construction of Facilities	[26.8]	27.7	27.5
Direct Full-Time Equivalent (FTE) Workyears	**[1,389]**	**[1,591]**	**1,572**

Note - FY 2001 and FY 2002 data in this section are for comparison purposes only. See *Mission Support* sections for more details.

PROGRAM GOALS

The two primary goals of this budget segment are to:

1. Acquire and maintain a civil service workforce that reflects the cultural diversity of the Nation, and is both sized and skilled consistently with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Space Science Enterprise.
2. Ensure that the facilities critical to achieving the goals of the Space Science Enterprise are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM): This program provides the salaries, other personnel and related costs, travel, and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The FY 2002 funding estimate for ROS includes $7.4M provided in the Emergency Supplemental to enhance NASA's security and counter-terrorism capabilities. The FY 2003 funding estimate is $4.5M. The salaries, benefits, and supporting costs of this workforce are covered in the Personnel budget, which comprises approximately 75% of the requested R&PM funding. Research and Operations Support, which covers administrative and other support, is approximately 20% of the request. The remaining 5% of the request is required to fund the travel necessary to manage NASA and its programs.

CONSTRUCTION OF FACILITIES (CoF): This budget line item provides funding for discrete projects required by components of NASA's basic infrastructure and institutional facilities; almost all CoF funding is used for capital repair. NASA facilities are critical for the support of research conducted by the Space Science Enterprise. NASA has conducted a thorough review of its facilities infrastructure, and determined that, 1) the deteriorating plant condition warrants increased repair and renovation efforts in order to avoid safety hazards to personnel, facilities, and mission, and 2) some dilapidated facilities need to be replaced. Increased investment in facility revitalization is required to maintain an infrastructure that is safe and capable of supporting NASA's missions.

ROLES AND MISSIONS

The Space Science budget contains funding for civil servants at Goddard Space Flight Center, Ames Research Center, Langley Research Center, Marshall Space Flight Center, Johnson Space Center, and Headquarters. Jet Propulsion Laboratory is a Federally Funded Research and Development Center; therefore, the Lab's employees are not civil servants, and their personnel and related costs are included in direct program costs.

Goddard Space Flight Center (GSFC)

The Office of Space Science provides approximately 52% of GSFC’s institutional funding. GSFC is the Lead Center for two of the four science themes in the Space Science Enterprise: Sun-Earth Connections and Structure & Evolution of the Universe. The objectives of Sun-Earth Connections are to seek a scientific understanding of the why Sun varies and to determine how solar variability affects life and society. Structure & Evolution of the Universe is comprised of three fundamental scientific quests: explaining the structure of the universe and forecasting our cosmic destiny, exploring cycles of matter and energy in the evolving universe, and examining the ultimate limits of gravity and energy in the universe. In support of these objectives, GSFC manages many currently operating missions, such as the Hubble Space Telescope, the Microwave Anisotropy Probe, and the Thermosphere-Ionosphere-Mesosphere-Energetics and Dynamics mission. GSFC also manages a large number of missions in development, including all missions in the Explorers program, missions in the Living With a Star program, as well as several major strategic missions, such as the Next Generation Space Telescope. GSFC also conducts world-class space science research in such areas as astrophysics, solar physics, high energy astronomy (x-ray and gamma ray), optical astronomy, microwave/infrared astronomy, and radio astronomy. Other activities include managing the NASA’s sounding rocket program and scientific balloon research program.

GSFC is a Performing Center for two of the four science themes in the Space Science Enterprise: the Astronomical Search for Origins and Solar System Exploration. In addition to managing two key missions in the Origins theme (the Hubble Space Telescope and the Next Generation Space Telescope), GSFC develops science instruments and technologies targeted at improving instruments, on-board spacecraft systems, and subsystems. GSFC has also conducted scientific research in support of the Origins program, planetary exploration, and investigations into other bodies in the Solar System.

Ames Research Center (ARC)

The Office of Space Science provides approximately 16% of ARC's institutional funding. ARC has the Agency lead role in Astrobiology (the study of life in the universe), which focuses on the origin, adaptation, and destiny of life in the universe. Research includes advanced laboratory and computation facilities for astrochemistry; planetary atmosphere modeling, including relationships to the atmosphere of the Earth; the formation of stars and planetary systems; and an infrared technology program to investigate the nature and evolution of astronomical systems. Development continues of the Stratospheric Observatory for Infrared Astronomy (SOFIA) for research to be conducted by various NASA/university teams. Research and development in advanced information technologies are directed toward significantly increasing the efficiency of SOFIA as it becomes operational. ARC provides critical testing capabilities for aerobraking and aerocapture techniques used in several Space Science missions, including the Mars Exploration Program.

Langley Research Center (LaRC)

The Office of Space Science provides approximately 4% of LaRC's institutional funding. Conduct a technology development program for advanced ultra-lightweight and adaptive materials, structural systems technologies, and analytical tools for significantly reducing the end-to-end cost and increasing the performance of space science instruments and systems. Continue studies and selected technology development for future planetary atmospheric flight vehicles including aeroshells, airplanes, gliders, etc. Develop active and passive sensor technologies and concepts for application in planetary atmospheric studies. Selectively develop laser, LIDAR, and passive sensor technologies and perform research for planetary studies in areas, which are related to our Earth Science role. Continues to provide analysis of spacecraft aerodynamics, aerothermodynamics, and flight dynamics for spacecraft entering planetary atmospheres (including Earth) in support of both spacecraft design and flight operations. Support the solicitation and selection process of the Office of Space Science's (OSS) Discovery, Explorer, and Solar Terrestrial Probes Programs; conduct reviews of candidate and selected missions and independent assessments of on-going space science missions to help ensure that OSS criteria for high quality science return within cost and schedule constrains are met. LaRC is also responsible for the design and development of atmospheric entry vehicle technologies for ongoing robotic exploration programs.

Marshall Space Flight Center (MSFC)

The Office of Space Science provides approximately 7% of MSFC's institutional funding. MSFC manages the Solar B and the GLAST Burst Monitor, and conducts fundamental research in six disciplines—cosmic-ray physics, gamma-ray astronomy, x-ray astronomy, solar physics, space plasma physics and astrobiology. MSFC manages the operation of the MSFC developed Chandra X-ray Observatory through the Operations Control Center and the Chandra X-ray Center at the Smithsonian Astrophysical Observatory in Cambridge, MA.

Johnson Space Center (JSC)

The Office of Space Science provides approximately 2% of JSC's institutional funding. JSC is responsible for leadership in the field of astromaterials and operates NASA's astromaterial curatorial facility for extraterrestrial sample materials. The Center supports the Agency's Space Science goals through research, information dissemination, and interaction with the scientific community. This research includes planetary science, astrobiology, space debris, and sample material handling. The primary focus is on the composition, structures, and evolutionary histories of astromaterials to further our understanding of the solar system and aid in the planning for future missions.

Glenn Research Center (GRC)

The Office of Space Science provides approximately 3% of GRC's institutional funding. GRC provides enabling technologies in the areas of power systems, on-board propulsion systems, air breathing propulsion, rocket components and integrated vehicle monitoring systems. GRC is the lead center for the Nuclear Power Program, and will perform a significant role in the propulsion programs managed by the Marshall Space Flight Center (In-Space Propulsion and the Nuclear Propulsion Program).

Headquarters (HQ)

The Office of Space Science provides approximately 11% of HQ's institutional funding. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE's across the agency. A more complete description can be found in the Mission Support/two Appropriation budget section